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ABSTRACT

Case studies examined the context and impact of training in three factories: a bakery, a circuit assembly plant, and a plant that produces microchips. Cookie-Foods, Inc. used Statistical Process Control (SPC) and a course on problem solving to increase the operators' productivity. Impact of the SPC program was limited, because workers who collected data did not know how the data were used. The course had only a limited impact on worker behavior because it was not connected to organizational change. Circuit, Inc.'s team members acquired skills on the job. Changes in the plant's function and mission within the parent company were limiting the team system as a vehicle for training. Intent on changing plant culture, Electro, Inc.'s management introduced all operators to a course on Deming's principles of quality control and organized seminars for supervisors. Seminars resulted in structural changes in the plant's process. Common themes from the case studies were as follows: (1) training is a vehicle for organizational development; (2) evaluation of training impacts should consider its ability to support organizational change and the change's depth and scope; (3) training cannot be separated from the economic and strategic context; (4) training must be linked to an organization's structure and process; (5) training programs partly reflect the ongoing politics of organizational change and development; (6) workers' competence is linked to the dynamics of a problem situation; (7) training must be based on principles of adult education; and (8) trainers cannot control the training encounter but must be open to surprises. (YLB)

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TRAINING FACTORY WORKERS:
THREE CASE STUDIES

Contract Report

Submitted to the Office of Technology Assessment by

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This contract report was prepared to be used as background material for the assessment on Worker Training.

The assessment entitled, "Worker Training: Competing in the New International Economy," was released in September 1990.

All opinions in this report are those of the authors and do not represent the views of the Office of Technology Assessment, U.S. Congress

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Executive Summary

This study examines the context and impact of training in three factories: a bakery; a circuit assembly plant; and a plant that produces chips. In the first and last case the author participated on the training team; in the second, the author, interviewing managers, workers and organizational development specialists, examined the challenges to training facing the plant.

The purpose of this study is to examine how training programs are designed and delivered and to assess what relationships such programs have to the broader tasks of organizational development and renewal. The following chart highlights the key training initiatives in each of the plants.

THREE CASE STUDIES

	Cookie-Foods	**Circuit, Inc.**	**Electro, Inc.**
Product	Cookies and crackers	Assembled circuits	Chips
Number of employees	1000	200	Up to 5000
Content of training effort	Problem solving skills, SPC, troubleshooting	(Planned) A range of social and technical skills*	Examining the supervisor's role
Depth and duration of program	Six classes. each lasting two hours delivered to two shifts, between seven and twelve per shift, a manager and supervisor	Ongoing four sessions each lasting two and a half days, attended by a total of 120 supervisors and 20 upper managers, including the plant manager and his deputy	Eight months

**Includes for example, classes in problems solving skills, software for specific machines, controller maintenance, shop floor scheduling skills, project management techniques feedback training.*

Below we briefly examine the context for training in each factory and then assess each program's impact.

Three Factories

Cookie-Foods, Inc.

Cookie-Foods, Inc. is part of a corporate group of a large conglomerate comprised of ten bakeries. Concerned with increasing competition for shelf space in supermarkets as the variety of cookies and crackers has grown, and facing the increasingly rapid introduction of new cookie lines throughout the industry, corporate management wanted to improve the quality of its products and each factory's ability to control their lines in the face of new product introductions. To this end the corporate staff asked the process engineering group to introduce a program of statistical process control and problem solving in the plants. The engineers ran experiments to assess why color, weight and size were sometimes out of spec, managers took a course in statistical problem solving and helped the engineers design experiments, and workers participated in the data collection processes. In addition, the managers at Cookie-Foods, Inc. hoped that by participating in SPC data collection and observing process trends on control charts, workers own control skills, their ability to spot and trouble shoot problems, would improve as well.

Yet both workers and managers agreed that the impact of the SPC program was limited. Workers collected data but really didn't know how the data was used. Many felt that the SPC program had little impact on their day-to-day work. Workers continued to rely on their tacit skills, the skill that comes with experience to do their jobs. Hoping therefore to build on the beginnings of the SPC program, management through the efforts of the organizational development specialist at the plant launched three problem solving teams and sponsored a pilot training program on problem solving skills and statistical concepts.

The course focused on problem solving skills, brainstorming, the logic of trouble shooting problems, the concept of control and experimental groups in experimental designs, basic statistical concepts and issues of group process and group dynamics. The course provided workers and managers with a common language for problem solving, so that in facing the differences that divided them they could draw on this language to work together. But this was only a beginning. Since the course at the time of this report was not connected to a broader process of organizational change, it only had a limited impact on worker behavior. The basic relationships between supervisors, workers and managers had not changed

Circuit, Inc.

Designed as a sociotechnical plant from its inception, Circuit, Inc. was manned by semi-autonomous teams. Most team members were multi-skilled, or "floor certified" -- able to perform all basic tasks from receiving to shipping and preventive maintenance. Skills were acquired on the job as team members instructed one another or rotated to other teams to acquired particular competencies. Team members were paid for the knowledge they acquired to become floor certified. Thus training and compensation were built into the fabric of the team and organizational process. Finally team members participated actively in the plant's policy process, participating for example in a task force for introducing the a new automated technology for assembling circuits.

Yet at the time of the study, changes in the plant's function and mission within the parent company were delimiting the team system as a vehicle for training. The plant was increasingly functioning as a ramp-up facility and a broker of knowledge about new process technologies for the plant as a whole. At the same time the introduction of automated assembly equipment was transforming shop floor work as operators did less manual work stuffing boards, and did more monitoring work supervising machines, tracking quality and locating trouble spots in the production process. The distinction between direct and indirect labor was becoming less meaningful. As a result, the team system, once the key to the development of worker skills, appeared increasingly insufficient to the new challenges of worker training.

There were three signs of stress on the team system. First, the declining distinction between direct and indirect labor, combined with some operators' wish to become white collar workers, was reducing workers' identification with their teams. Second, while at one time each of three teams had their own machinery, the shift to automated machines, called surface mount technology, and the prospect of introducing an even newer process technology in the near term future, led plant management to invest in only one process line. This meant that the teams had to share the new machinery thus reducing each team's sense of integrity. Third, working to ramp up new products, operators participated increasingly in projects rather than teams, so that their connections to engineers, accountants, purchasing was becoming as important as their link to team members.

The plant's management recognized this and at the time of the study were developing a significant "reskilling" program to retrain workers. Recognizing that classes offered in the past had not been linked to a vision of the factory's future, the human resources staff developed a plan for linking classroom training to the future roles of operators and engineers. The study concludes with the hypothesis that plants which once relied on the team system to integrate working and learning will have to find new ways to use classroom training as an increasingly important vehicle for worker and organizational learning. Perhaps the structural gap between the classroom and on the job experience can be bridged, if the entire curriculum is designed to fit with and adapt to a shared understanding of workers' current and future tasks and skills.

Electro, Inc.

Intent on changing plant culture, the plant's management introduced all the operators of the plant to a day-long course on Deming's principles of quality control. Taking Deming's advice and admonitions seriously, management eliminated time clocks for operators with good attendance records, and disbanded the industrial methods unit which rated operator's jobs. They hoped to "drive out fear," as Deming had argued, and to establish a more participative climate. At the same time, responding to an increasingly competitive market, the plant had introduced a Just-in-Time program to minimize inventory and maximize asset turns.

Yet ironically, at the Deming sessions attended by upper managers and supervisors as well as operators, supervisors were often attacked by the operators as being the source of all the problems. Feeling scapegoated, supervisors complained and withdrew from a shop floor council that depended on their participation for its effectiveness. Concerned that supervisors were losing their role and were alienated from the plant, plant management asked a training team to conduct a seminar for the supervisors. It was hoped that just as the Deming seminars have given the operators a voice and place, the supervisor's seminars would help supervisors reconnect to their roles while helping them identify with the changing climate and structure of the plant.

The seminar was organized less as a class and more as a series of occasions for inductive learning. Based on research into the supervisors' role at the plant, the training team, worked with the supervisors to assess their changing role, to examine their links outward and upward as well as downward to their operators, and to help them develop the interpersonal skills they needed in a more complicated plant environment. In addition upper managers, including the plant manager and his assistant for all operations, attended each session, while about ten other upper managers attended on a rotating basis.

The seminars resulted in structural changes to the plant's process. For example, the plant's management introduced more vertical meetings between supervisors, their bosses and their bosses, the labor relations group held seminars with the supervisors on interpreting the union contract, and supervisors were given a higher budget limits for withdrawing materials from the storeroom. Feelings about the seminar were good; supervisors rated the first one good to excellent. But the plant was going through so many changes -- J-I-T systems, the emergence of more powerful production control and support groups, changes in the parent company's organization -- and was facing such intense competition in the marketplace, that it is difficult to disentangle the impact of the seminars from the broader challenges it faced.

Conclusions

The three cases discussed in this report -- their presenting problems and training vehicles -- are all quite different. Yet several common themes exist across these cases, highlighting challenges to training in a wide variety of industrial settings. Eight themes are of particular importance.

First, we cannot think of training as a narrow activity confined to classroom experience and designed to give workers particular technical skills. This image of training is not wrong, rather it is too limited. *Training is a vehicle for organizational development and therefore facilitates organizational functioning in many ways.* It helps people take up new roles rather than just new skills, it helps links roles and levels together in new ways, it creates a shared language of problem solving which helps people from different functions work together, it helps shape a climate in which people believe that in fact management "cares" about its people. Technical skill acquisition is one important subset of training's broad purposes, but it is only a subset. Thus consider the following chart.

	Cookie-Foods, Inc.	Circuit, Inc.	Electro, Inc.
Training to help give new problem solving skills	X	X	
Training to give new social system skills	X	X	X
Training to help shape new roles	X	X	X
Training to create an integrating language of problem solving.	X		
Training to improve authority relationships			X
Training- to give new technical skills		X	
Training to help people think of themselves as learners	X		X

As this chart suggests, at each factory training served more than one purpose while the focus of training differed among them. For example, the training at Electro Inc. was specifically designed to stabilize authority relationships between the supervisors and upper management, while also helping to improve the supervisor's interpersonal skills. At Cookie-Foods, Inc., by contrast, the training focused on problem solving skills, and by helping to link the bakers to the SPC program, it provided workers and managers with the beginnings of a common language for solving problems. Finally, at Circuit, Inc. the prospective training program (recently adopted as one part of its human resources program) focuses on technical and social skills that workers will need in the plant's emerging project culture.

Second, in evaluating the impacts of training we cannot therefore simply look at skills acquired. Indeed, as the case of Cookie-Foods, Inc. suggests, unless skills are reinforced through a new set of roles and relationships, the training will have ultimately "failed" even though trainees can pass competency tests upon completion of a course. Similarly, as the case of Electro, Inc. suggests, in assessing the impact of the seminars, we need to look at the organizations changes upper managers introduced that reshaped the relationships between supervisors, managers, and operators. This suggests that training's impact depends on both its ability to support an organizational change effort *and* on the depth and scope of the organizational change itself. The former measures its efficiency, the latter its ultimate effectiveness. The following six-fold table exemplifies this approach.

ASSESSING TRAINING'S IMPACT

*Training's contribution to an organizational development (OD) program**

		High	Med.	Low
The impact of the OD program on organizational change	High		Electro	
	Med			
	Low	Cookie-Foods		

***Circuit, Inc's new training programs are still too new to be evaluated.**

Third, this means that in trying to understand training's impact we cannot separate it from the broad economic and strategic context which shapes, enables and delimits all efforts at organizational renewal and development. Thus for example, at Cookie-Foods, Inc., a sudden expansion in production and hiring made it difficult for the organizational development specialist to invest time, effort and attention in the task force teams he had helped start. Similarly, the challenges to training at Circuit, Inc. were shaped by the plant's strategic role in the company.

Fourth, as this approach suggests, we must acknowledge the problem and challenge of linking the training process to an organization's structure and process. In the case of Cookie-Foods, Inc., the operators could not transcend their tacit approach to problem solving, they could not use the new formal techniques, unless new relationships between managers and workers emerged in the bake shop. Similarly, at Circuit, Inc., the development of new skills challenged two features of the organization design -- the team-based system for allocating jobs and training opportunities, and the pay-for-learning system for regulating learning and upward mobility. The new skills were linked to project tasks which cut across the teams, while training had to take place increasingly in the classroom rather than on the job.

Finally, at Electro, Inc., the senior management faced the problem of taking the learnings and experience from the training setting and changing actual organizational practices. The training environment at Electro, Inc. could function at most as a transitional space between insight and action, but it could not substitute for action within the organization itself.

Fifth, training programs will partly reflect the ongoing politics of organizational change and development. They are not simply technical responses to technical problems but rather reflect tensions and compromises among the different interest groups in the organization. For example, at Cookie-Foods, Inc., senior management's uncertainty about the impacts of SPC of capital spending delimited its impact, while the human resource manager's plans for modernizing the personnel function were implemented in a traditional industrial relations system. Similarly, at Circuit, Inc., management's conception of training and skill development took place against a backdrop of some workers' desire to get out of factory work and learn more white collar skills. Finally, the political realignments that the Deming program stimulated at Electro, Inc. -- i.e., the coalescence of the operators and upper managers (seemingly) against the first line supervisors -- alienated the latter and led to the development of supervisory training program. That program was thus embedded from the start in the politics of intergroup relationships.

Sixth, workers' competence, their ability to learn and practice skills, are linked to the dynamics of a problem situation, as well as to their abilities or the objective complexity of the job. To be sure, workers who repair machines need to understand how the machine works -- this is objective knowledge. But their capacity to be competent, to translate abstract knowledge into competence to perform as well as to learn, is inextricably linked to the group processes that shape what they observe, how they feel, what risks they take, what they fear.

We cannot think of training as simply classroom activity in which knowledge is "injected" into people. Rather training, when it is successful, authorizes people to "try on" some new skills, some new practices, and to rework their relationships so that these new practices fit into their environment. Training stimulates a process of development and is therefore the beginning rather than the end of skill acquisition.

Seventh, since workers are adults who need to feel authorized to practice in new ways, training must be based on the principles of adult education. Adults learn when they are offered genuine choices, and when the new knowledge can improve their practice. Then they can link what they currently know to what they wish to learn. Training, to be successful, cannot be based on practices derived from the training of children, where students are given few choices, experience is ignored, and the trainer is the all-knowing expert. To be sure, classroom training is important, and as we saw at Circuit, Inc., can become more so as technologies change with greater frequency. Rather, the roles people take up within a classroom must be less stereotyped, less based on the teacher-pupil model of public schooling.

Thus, for example, while working within a modified seminar format, the instructors in designing the training program for Electro, Inc. developed the training materials from the experience and cases of the supervisors themselves. Similarly, at Cookie-Foods, Inc., the instructors designed experiential learning activities which opened up several paths for learning, rather than just one.

Indeed, this explains why "on-the-job training" remains so powerful and effective. The informal teacher or mentor teaches in the context of practice as actual problems emerge. Through observation, he or she takes account of the "apprentice's" prior experience and strengths, and authorizes the apprentice, by sanctioning practice runs and trials by fire, to try on new skills without being afraid of being ridiculed for making mistakes. New training mechanisms should not simply dispense with these features of on-the-job training but rather find ways of incorporating them within more systematic and cost effective methods for teaching and learning.

Eighth, this different approach suggests that trainers cannot hope to control the training encounter but must instead be open and vulnerable to the surprises that genuine learning produces. Such an approach to training may prove difficult to achieve. The economics of training always pushes in the direction of designing repeatable events with known inputs and measured training outputs. As training becomes even more significant, we need to find a new melding of the formal and the informal, the off-the-job and the on-the-job, the instructional setting and the facilitating setting, to effectively and efficiently help companies and their employees develop and apply new technical and social skills.

Introduction

As new technologies emerge with increasing rapidity and companies change their social systems and "cultures," managers are relying increasingly on training to stimulate individual and organizational development. The following report, based on three case studies, examines the microdynamics of training by studying both the context and the delivery of training in three factories. In two cases, the author participated actively on a training team. In the third, the author studied the challenges to training through the traditional methods of case study research. The goal of this report is to step behind the curtain of the training encounter and to assess how it is done, what is accomplished, and how it might be improved.

The Three Sites

The following table presents the context for the three case studies.

Factory	The Industrial Process	The Presenting Problem	The Training Vehicle
Cookie-Foods, Inc.	Baking	Teach diagnostic problem solving skills	Small classroom setting
Circuit, Inc.	Making circuit boards	Teach project skills, and process operator skills	Classroom and on-the-job
Electro, Inc.	Making chips	Teach supervisory skills	Seminar

The three sites varied in size, though each was very capital intensive. The bakery took up several city blocks and employed 900 employees. Circuit, Inc. employed about 250 people and Electro, Inc., at its peak period of production, employed over 5000 people. In the first case, the author participated on an instructional team, training about 15 bakers over six weeks the basics of diagnostic problem solving. In the second, the author, taking the role of the case study researcher, toured the plant twice and interviewed a cross section of 15 plant personnel, managers, operators and trainers. In the third case, the author participated on an instructional team which designed and facilitated a seminar for over 100 supervisors and their bosses over the course of one year. In each case, the author working with others interviewed a cross section of employees before helping to design and conduct the training program itself.

The cases are linked along a continuum of the scope and scale of effort. At Cookie-Foods, Inc., the instructional team worked with a small group on learning to diagnose or troubleshoot problems. Such skills are typically practiced at workers' individual work stations within the context of the small group or team.

At Circuit, Inc., by contrast, plant management was developing a training program that could help operators take roles in a project system as the factory, responding to the new technologies and the new markets, was increasingly producing low volume prototype products. Such project skills are typically practiced in intergroup or interdivisional settings.

Finally, in the case of Electro, Inc., senior management, deciding to improve the supervisory skills of its first line supervisors, sponsored a year-long seminar which involved managers from all levels of the organization and across several divisions. The challenge of first line supervision was thus embedded in the broader problem of cultural change for the factory as a whole, of learning to develop and take up new norms and roles.

Thus, the three cases highlight both some of the similarities and differences facing trainers as training programs are applied to different problems and different scales of factory life. The following table highlights these differences.

Factory	Core Theme	Group Context
Cookie-Foods, Inc.	Learning diagnosis	Small group
Circuit, Inc.	Taking up project skills	Intergroup
Electro, Inc.	Developing new norms and behaviors	Large group

The report is divided into four sections. The first three sections each present a case study, and the last section assesses the common themes that cut across the different case studies.

I. Training the Process Operator: Making the Tacit Explicit

Walking into the bakery of Cookie-Foods, Inc., you notice the smells of chocolate, ginger, and vanilla. The bakery is spotless, the floor is bare, and your mandatory hair net keeps bits and pieces of your hair from getting into the dough. Line after line of large ovens, each a block long, stretch across the bakery floor. Moving on a roll through the ovens, the dough is cut, shaped, iced, and baked. The bakery is capital intensive; one "machine-captain" prepares the dough and one baker controls an oven. Between the two of them they can produce endless rows of cookies and crackers.

Cookie-Foods is part of the corporate group, Food Inc., which is composed of ten food plants. As a successful and productive bakery, Cookie-Foods operates at full capacity producing a broad line of cookies. An old and venerable institution in the neighborhood, the majority of Cookie-Food's unionized bakers, machine captains and mixers have worked there more than 25 years; only the men and women in the packing department have been hired recently. The work force of about 900 people is composed of both men and women, whites and blacks, though the majority are white men.

The Case

The history of technology and work has been shaped prominently by management's attempts to rationalize workers' skills, to study them scientifically and then create techniques or machines that insure such skills are deployed without error. While it is a relatively straightforward task to analyze physical activities such as pulling, threading, and drilling, it is harder to examine the mental activities of observing, assessing and deciding. How can managers rationalize control tasks where operators simply monitor and correct an industrial process? How can they direct their attention and improve their ability to diagnose problems?

The following chapter examines how Cookie-Foods, Inc.'s plant and corporate management used Statistical Process Control (SPC) and a course on problem solving to increase the operators' productivity. The former was designed to redeploy their attention, the latter to improve their ability to troubleshoot their processes. Just as time-and-motion methods were once used to regulate operators' physical activities, so are SPC and troubleshooting techniques being used to regulate the operators' *mental* activities, to make them more systematic. But as we shall see in this case, unless matched by social system changes that link operators to managers and process engineers in new ways, such efforts will have only limited effects.

This chapter is divided into four parts. The first examines the dilemmas managers and operators faced in introducing and using SPC. The second examines the problem solving course that management sponsored as a complement to SPC; we will review the course's content and the classroom process. The third section examines key issues in teaching process operators to become better problem solvers. The chapter's final section links the training program to the broader issues of organizational development.

Modernizing the Craft Process

Machine captains, bakers and mixers (who work on the top floor, overseeing the mixing and fermentation of the dough) have "craft skills." Operating largely on the basis of feel and experience, they adjust pressure, temperature, line speed and heat to insure that the cookies are baked properly, are of uniform weight, and can be packed without breaking. Bakers who work at the back end of the process, after the dough has been loaded onto rollers, control eight oven zones. The first zones are used to control the height of the cookie, the middle ones control the moisture, and the latter zones determine the color. Watching dials, using scales, and visually observing the dough at one end and the cookies at the other (Are they burned? Are they too thin? Do they look too high? Are they too heavy?), the bakers adjust valves, dampers, and speed controls to produce uniform cookie sheets.

Machine captains, who receive the dough in batches from the mixing room, regulate the flow of the dough onto the line, and control the operation of a roller cutter which presses the dough into shapes. Most importantly, they have to be sure that the dough is spread correctly across the roller so that it is thick enough to cut a complete cookie, but not so thick that the roller will clog.

The machine captains and bakers are classic process operators, relying on their experience, their sense of touch, and the manual adjustment of valves to control a process. If, for example, the cracker that comes out at the end of the line is too crisp, they have to figure out a reason. Is the speed of the line too slow so that the cracker spends too much time in the oven? Is the dough too dry, or the temperature too high? Or perhaps the crackers are within specification but, appearing slightly too crisp to the trained eye, the baker discovers that temperature and speed are counteracting each other: the speed is too slow but the temperature is below average. The machine captain and baker, in other words, control a process by continuously adjusting a *series* of controls.

The Limits of Craft Skills

Corporate management, however, was not satisfied with the sophistication and accuracy of the control process. The market itself had become more demanding. Large bakeries were producing a wider array of cookies and crackers to maintain market share in a competitive environment, while customers expect consistency and uniformity in any brand of cookie and cracker. As one product manager noted, "There has been a tightening of specifications. You reject more product even though your equipment has not changed." In addition, the theory of fermentation and the science of using doughs and predicting their characteristics are still poorly understood. Changes in the wheat crop or in the composition of city water created unpredictable control problems for mixing and baking. Finally, since the work force has an average of 25 years of experience, the managers of the bakery worry that when these workers retire, the bakery will lose its fund of tacit skills and knowledge. Management needs to modernize the control process, to understand it more explicitly, to ferret out the links between doughs, temperature, and the composition of the final product so that its products are consistently of high quality.

Statistical Process Control (SPC)

To accomplish these objectives, corporate management established a two-pronged program. First, they set up a process engineering group, which conducted studies in several factories, to map the links between variations in dough and control variables such as temperature on the one side and the features of the final product on the other. Using regression analysis and experimental designs, the group could determine the frequently multiple causes of why an oven, for example, produced burned crackers or cookies with a short shelf life. Plant management participated in these studies by defining the key production problems they wanted to address, by helping the process engineering group collect data and design experiments, and by participating in a year-end three-day seminar at which representatives from several factories presented the results of their work.

Second, to launch its effort and prepare management for the experimental work itself, the group sponsored training programs for supervisors and managers in general problems solving techniques, focusing on such methods as brainstorming, problem mapping and the statistical process control. Management and supervisor personnel from about ten factories attended these training seminars over the course of one summer.

Third, to collect the data required for these studies, plant supervisors and some members of the corporate statistical control group taught bakers and machine captains the rudiments of statistical process control. They developed control charts which showed the target of a control variable (such as temperature or weight) in the middle of the chart, while displaying its upper and lower limits as bars above and below the target. Whereas in the past operators would simply write down control readings, they would now record the readings and be able to see if there was a trend away from or toward the target variable. Floor supervisors who had taken the SPC course, which covered the basic concepts of range, average, variance, and normal distribution, taught these concepts to bakers and machine captains on the job. The training was strictly informal, no classes were held, and the supervisors themselves received no formal instruction on how to teach these core ideas.

The Goals of SPC. The managers at Cookie-Food had two hopes for the SPC process. First, by continuously tracking deviations from target colors and weights (color is measured by the amount of light that gets through a target cookie) and by doing special studies of deviations from other control variables such as temperature and moisture, the plant could develop an empirical understanding of how variations in input and output were connected.

Second, by providing operators with range data, the plant hoped to increase the sophistication with which operators controlled the baking process. Managers felt that operators, focusing too much on targets rather than on trends, frequently *overcontrolled* a process. If, for example, six process variables controlled baking, it is unlikely that all six will be exactly at their target levels. Instead, some will be off, which frequently means that others must be off as well to create a balanced line. As one supervisor described it, "[Let's say] the baker is looking at his product. He'll say, 'They're dark so therefore I have too much heat; I have to take the heat off.' But maybe his weight is light so they're burning up, they can't handle all the heat that is used for the *proper* weight." Similarly, as we saw before, if dough moisture is too high, oven temperature will have to be a bit higher and perhaps line speed will have to be bit slower to prevent the cookies from being too soft. The line must be "tuned," which means that most of the key variables will be *off*-target. If bakers simply focus on the target, they will create an unbalanced line which results in the need for more adjustment. By focusing on ranges rather than targets, SPC could help operators develop a more sophisticated view of how to keep the process in balance, of how to "tune" it. Indeed, the quality control supervisor for the day shift felt on the basis of his own sampling that SPC had helped bakers reduce the number of defective cookie batches they produced.

In addition, some supervisors felt that when focused on targets rather than deviations and trends, operators experienced the targets as normative "commands" to keep the process at the targeted levels. This meant not only that they might overcontrol the process, but that they interpreted deviations from the targets as a sign that their work was at fault. Consequently, as the QC supervisor noted, operators would frequently note a deviation, correct it, and only then record the *corrected* state of the variable. Thus the plant lacked a record of its process deviations and could not learn about what combinations of levels and values created a stable process and an acceptable product.

In sum, by introducing SPC, managers hoped to collect data that could help them examine the baking process scientifically while improving bakers' understanding of their control tasks. The following table summarizes the hoped-for shifts in operator behavior.

From	To
focus on target	focus on deviation from target
overcontrol a process by focusing on targets in isolation from each other	tune a process, by accepting a *systematic* set of deviations from targets
targets as normative commands	targets as information for learning

The Workers Respond

While the QC department had data confirming that SPC was helpful, many bakers were skeptical. When a group of them were interviewed at a team meeting, most complained that they did not know what happened to the data they collected (they thought it went into some computer), and felt as a consequence that it only gave them more paper work. When two bakers were interviewed at the ovens, one felt that the SPC was helpful but another, an experienced old hand in the bakery, felt that it failed to address the more important problems of machinery maintenance and job design. Skeptical of those operators who defended SPC, he argued that the bakers, for example, don't really measure the weight of the batter and just "put down what [number] they measured the last time." He then argued that a protocol for taking three measures of weight from the roll was due to the fact that the heat in the oven was irradiated in an unbalanced way, and that management should simply fix the oven. Talking about his experience, he then noted, "The bakers used to clean out their own ovens but they gave the job to plumbers who don't want to do the work."

Finally, he argued that the control charts were not useful and he could rely on his eyes. Similarly, another operator argued that while managers seemed interested in improving the bakers' skills, the bakers had lost some prior freedoms. For example, he noted that bakers once were able to walk from the bake shop to the packing area. They were then able to see if the packers were having problems that implicated the baking or mixing process. Now they were no longer free do to so.

In short, relative to the range of issues they faced, their considerable process skills and the fact that little ensued after they filled out the SPC charts, bakers discounted the significance of SPC.

Some Managers Respond

Several managers agreed with the bakers. Both a product manager and a human resource professional noted that the data, collated by computer, were viewed primarily by the plant managers and were used largely by the industrial engineers to tease out the links between inputs and outputs. The bakers did not see the cumulative results of the data collection process. Similarly, the product manager noted that senior managers of the company were divided on the wisdom of introducing SPC. While some felt that the bakers' skills would be improved, others felt that in identifying problems and areas for potential improvement, bakers would simply create unwanted pressures for capital spending in the plant. Both managers agreed that the SPC program had been implemented in a less than supportive setting.

In short, SPC had been a partial successs. The process engineering group was conducting prodution experiments, managers had learned some problem solving skills, and operators were familiar with the SPC charts. Yet as the above comments suggest, many felt that both SPC and the broader problem solving process had not been institutionalized. It was a program appended to the factory system without becoming an integral part of it. Indeed, attending a meeting of factory representatives sometime after our own effort had been completed, the head of the process engieneering group said that it was difficult for him to get the factories to really "own the program." They cooperated but the engineering group had to take all the initiative.

Nonetheless the human resources manager, Jeff Berg, part of a new cohort of younger managers intent upon modernizing the factory's personnel function, had decided to sponsor a set of worker task forces to help shape a climate of participation and to support the thrust of the SPC program. Consisting of about eight packers and bakers, and attended periodically by supervisors and other line managers, the workers in these task forces focused on production problems in the plant. For example, at one meeting of a task force, they discussed the problem they were having with the glueing process on a box machine. The plant management, dissatisfied with the machine's performance, were thinking of contracting out the box-making job. After examining the problem, the task force members devised a method for insuring that the glue was placed smoothly on the boxes. In doing this, they stopped the managers from contracting out the box operation, and saved workers' jobs.

Attending a citywide conference on adult literacy, Jeff Berg met some staff members of the Literacy Research Center (LRC) of the University of Pennsylvania. The latter suggested that they work with Berg and Cookie-Foods to see if the concept of adult literacy could be applied fruitfully to problem solving skills as well as to reading and writing. Berg, interested in supporting the SPC process and in deepening the plant's commitment to involving workers in problem solving, agreed. The LRC then approached the Wharton Center to see if the two groups together could collaborate with Berg and develop a pilot course on problem solving at the bakery.

After several meetings, the LRC, the Wharton Center, and the bakery's management agreed to jointly sponsor a course on problem solving for bakers and machine captains. The course was conducted over a period of about three months. Two instructors met with two classes in successsion, each class lasted about two hours. Class size varied between eight and twelve people, depending on shift schedules. A manager attended the early sessions of the course, one supervisor and Jeff Berg attended all the sessions.

The Course

The Scientific Model of Problem Solving

While illuminating the "soft side" of problem solving, such as inhibitions to creative thinking, the group process, and the links between experience and thinking, the course was designed centrally to help the bakers think about and understand the process of *rational thinking and scientific experimentation.* The key metaphor for the course was "diagnosis," or more colloquially, "troubleshooting" through which workers identify the basic cause of a problem. In this sense, the course was consistent with management's attempt to lift the bakers' process skills from the realm of the intuitive and tacit to the domain of the rational and explicit. Bakers would be more effective if they could learn to think more systematically about how they thought, if they could observe their own observation process. By learning such processes and methods, they could join management and the industrial engineers in progressively transforming a craft process into a scientific one.

Adult Learning Principles

Focused on the broad concept of solving problems, the course was organized into four main blocks: identifying constraining assumptions that limit creativity; proposing possible causes for a problem; mapping the causal structure of a problem; and testing hypotheses. The pedagogy was based on the principles of adult education: instructors emphasized application rather than abstract theory; they used non-work as well as work examples; they designed experiential exercises so that participants could learn directly from their classroom experience; they highlighted the role that groups and group processes play in problem solving; and they asked course participants to critique each module of the course. In effect, the course was based on the principle that adults learn best through action, application and assessment.

The course was taught once a week for six weeks, with separate sessions held for first and second shift workers. Depending on shift schedules, between five and ten bakers and machine captains attended each session. In addition, a supervisor, an area manager, and Jeff Berg attended most of the sessions. Each session lasted between one and a half to two hours.

The Brainstorming Module

The course was organized sequentially with each module providing a key building block in the participants' growing understanding of the problem solving process. The first two modules highlighted how tacit or nonconscious assumptions can inhibit problem solving. The third highlighted the role of divergent thinking in generating alternative hypotheses. The fourth focused on determining the location of a problem by going from general to specific cause, and eliminating possible causes by using "controls" or control groups. The fifth showed participants how to create a structural map of a problem to facilitate the search for a solution. And the sixth showed participants how to use statistical reasoning to scope out a problem.

The appendix to this section contains four inserts which, displaying the materials for the third module, convey the texture and feel of the course. The module was designed to teach participants brainstorming as a method for creating a broad list of possible causes for a problem. The instructor introduced the brainstorming method, and created a brief simulation to show what happens when people try to think while being evaluated. He then had the participants brainstorm to identify the possible causes of a "traffic jam" and a "power outage in the home." Finally he asked them to brainstorm to the cause of burned cookies on a particular line in the bakery. The first insert shows the instructor's guide, and the second is a synopsis of what actually happened in the two sessions. The third gives some samples of the participant's brainstorming efforts. And the fourth is the summary sheet of the module which was distributed to the participants at the next session. The reader can consults the appendix to understand the instructional process in detail.

Learnings from the Brainstorming Module: Content and Technique

While participating in the brainstorming module, the participants examined four themes. First, to avoid ruts and the pitfalls of overly constraining assumptions, groups can use brainstorming to begin thinking broadly. Second, problem solving mobilizes feelings of both evaluation and blame, which inhibit thinking. Third, if a group pursues one "seam" of thoughts and ideas it may miss some obvious possible causes which lie in some other "seams." For example, in brainstorming causes to a "power outage in a house," both groups spent a great deal of time examining physical causes, such as a lightning storm, a felled tree, etc. Only toward the end of the brainstorming process did they hit upon the idea that a house may lose its power because the owner has not paid the bill. They examined physical causes in depth but ignored social causes until the very end. Fourth, problem solving is ineffective unless a group keeps tracks of its thinking. Without a statement of assumptions, or a written record of prior attempts, groups repeat themselves.

In teaching brainstorming the instructor focuses on the process of learning as well as on specific ideas and technqiues. For example, to highlight how a climate of blame and evaluation inhibits problem solving, the instructor took up the role of an angry supervisor rejecting "stupid ideas." This exercise worked particularly well in the session for the second shift. Debriefing the simulation, the participants noted that the instructor could create silence while stimulating a half-joking argument between a (real) supervisor and operator in the classroom.

Second, in both sessions, the participants experienced the problems of thinking in groups. While brainstorming permits people to have ideas they feel tentative about, participants frequently felt *inhibited* when practicing brainstorming. Thus in debriefing their brainstorming to the possible causes of a traffic jam and power outage, some people noted that they felt silly in saying a particular idea. Others noted that they felt less productive than the group and had a hard time entering the conversation, while others acknowledged that in contrast to the rules of brainstorming, it was hard to *not* evaluate someone else's suggestion.

Third, using the method of experiential learning, the instructors asked participants to first brainstorm to a fictitious example, i.e., the "possible causes of a traffic jam," and then to brainstorm to a real problem, e.g., the causes of a burned cookie batch. Reflecting on their experience with both, participants in the first class noted that brainstorming on the second example was hard because "it is actually happening...it is less of a game," that the brainstorming process was not as spontaneous or playful, and that "there was lots of holding back." The instructor suggested that participants experienced the two exercises differently because the latter created a sense of stakes; people's competence was exposed because they were working on a real problem.

Fourth and finally, the participants evaluated their experience and the module at the end of the session. Some took this period of evaluation as an occasion to review their own experience. One participant noted how she fell silent in the last brainstorming exercise, for fear of looking stupid. Another used the review session to link his experience in the class to his experience in the bakery. He argued that too frequently, it is the foremen rather than the bakers who are involved in problem solving. Finally, other participants used the review period to critique the module. For example, one participant thought that supervisors should attend the course, and another, suggesting that he now had a better understanding of the course's purposes, noted that the course seemed designed to "expand your thinking."

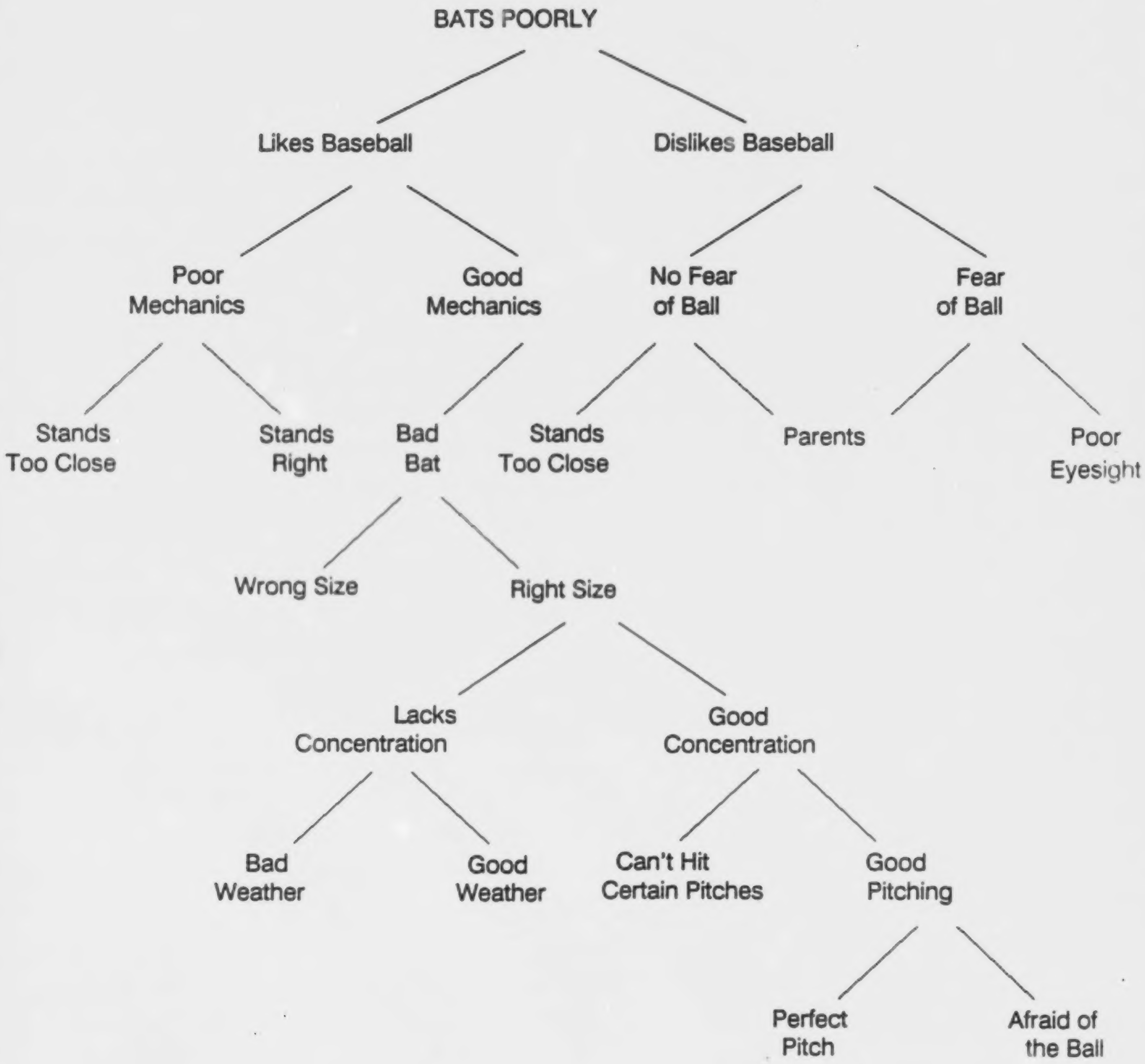
What Does Training Do?: Some Hypotheses

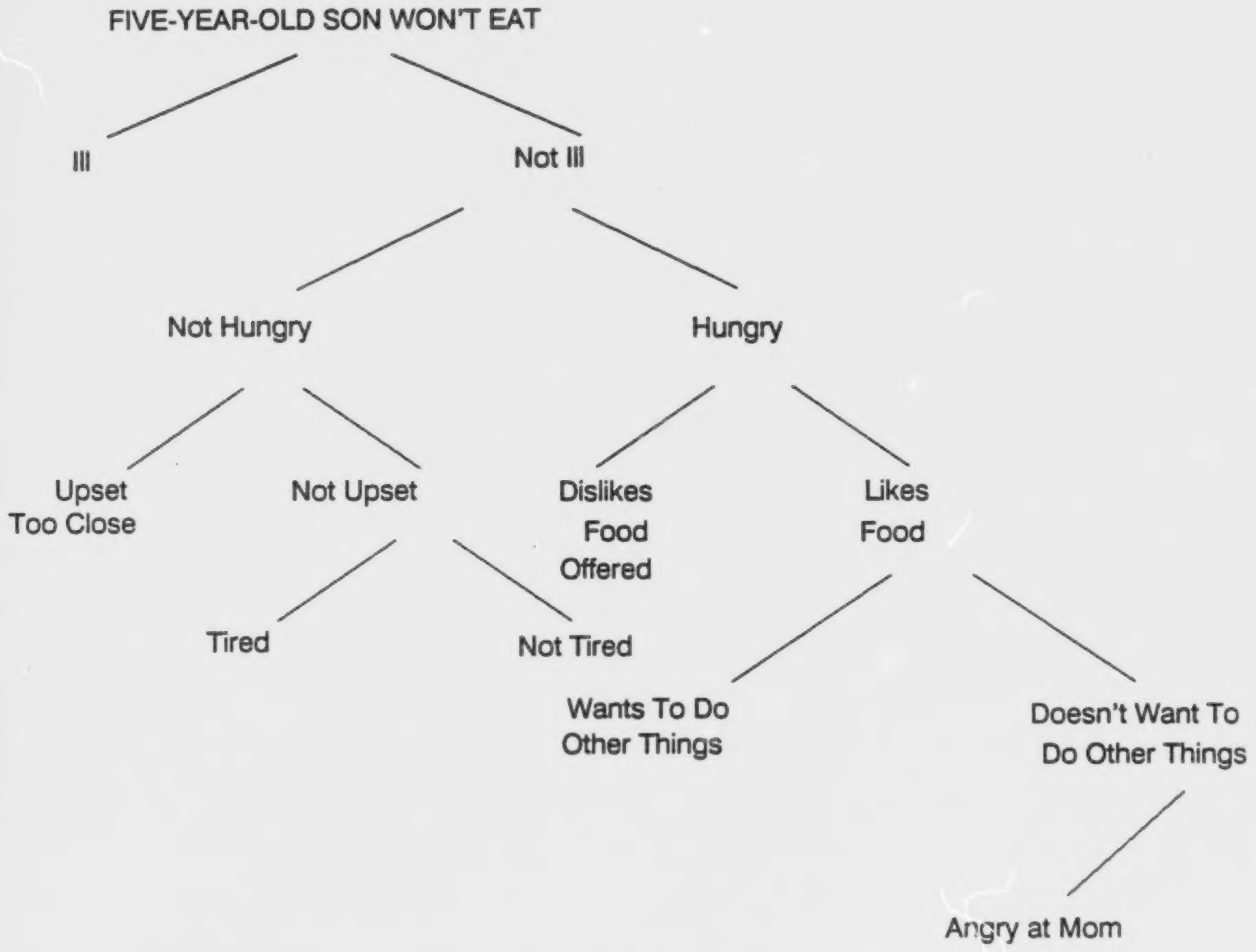
Each module was designed to deepen participants' understanding of problem solving by leading them through experiential exercises and offering work and non-work examples. Three broad themes, both about the training process and about training operators in problem solving skills, emerged from this experience. Since these themes are based on a single case study, they should be used as *hypotheses* for further study and analysis of other cases of training.

Making the Tacit Explicit

First, the bakers solve problems every day. As we have seen, they are constantly adjusting process variables on the basis of their implicit theories of cause and effect, in order to maintain a steady state. But they do so tacitly, without an awareness of how they think. Thus, the first and most important purpose of a course on problem solving is to make the tacit explicit, to unfold the logic of the problem solving process itself, to highlight the links between divergent thinking, testing assumption, and eliminating possible explanations.

Our module on mapping the causal structure of a problem highlighted the salience of making the tacit explicit. Building on their learnings about going from the general to the specific in identifying the possible causes of a problem, the instructor introduced the class to the use of troubleshooting trees. Using nonwork examples and later a work example, the participants were asked to create a tree for such problems as, "The boy bats poorly," or "The child won't eat." They produced the following trees.


BATS POORLY
Likes Baseball
Dislikes Baseball
Poor Mechanics
Good Mechanics
No Fear of Ball
Fear of Ball
Stands Too Close
Stands Right
Bad Bat
Stands Too Close
Parents
Poor Eyesight
Wrong Size
Right Size
Lacks Concentration
Good Concentration
Bad Weather
Good Weather
Can't Hit Certain Pitches
Good Pitching
Perfect Pitch
Afraid of the Ball


FIVE-YEAR-OLD SON WON'T EAT
Ill
Not Ill
Not Hungry
Hungry
Upset
Too Close
Not Upset
Dislikes
Food
Offered
Likes
Food
Tired
Not Tired
Wants To Do
Other Things
Doesn't Want To
Do Other Things
Angry at Mom

The process and outcome of constructing these trees were striking. Two themes are important. First, the participants took quickly to the technique and thoroughly enjoyed it. They tackled the exercises with zest and thoroughness. The challenge of mapping out a logical set of connections engaged them.

Second, by pushing them to create as many branches as possible, the tree mapping exercises forced them to consider both as wide a set of possible causes and as detailed a set of causes along any branch. For example, in working (at first unsuccessfully) on the problem of "The girl scout doesn't sell enough cookies," participants began with a narrow set of possible causes, focusing primarily on her behavior and her discipline, not considering the neighborhoods in which she sells, or the selection of cookies she offers. When the instructor critiqued their work and challenged them with a new set of problems, they were able to create maps that showed the linkages between a wide array of causes and the problems under study.

In general, we suspect that in the absence of techniques such as mapping the causal structure, operators tend to focus on one seam of thought to the exclusion of others. As in the "Power out" brainstorming exercise, they may, for example, focus on the human side of a problem or on the technical side -- but rarely on both.

The links between the tree maps and tacit process skills are suggestive here. Process operators are problem solvers, but their strengths are their weaknesses. Operating at the tacit level and relying on sense data, they may have too narrow a view of a problem and fail to think in broad system terms. Sensory data confines problem framing and problem solving data to a narrow envelope. By making cause-effect thinking explicit and by engaging the conscious rational mind as well as the pre-conscious nonrational sensory process, problem solving or diagnostic technique can expand the horizon and competence of the process operators.

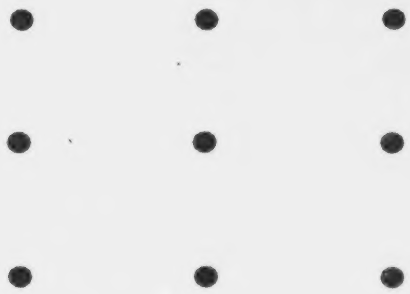
Problem Solving and the Group

Second, we hypothesize that the group process and the exigencies of group life are always operating either explicitly or implicitly -- that in facing problems, operators have an image of what they are authorized to do or say as they approach a problem. Training programs which don't take this into account may appear to impart skills, but will fail in helping operators apply them at work.

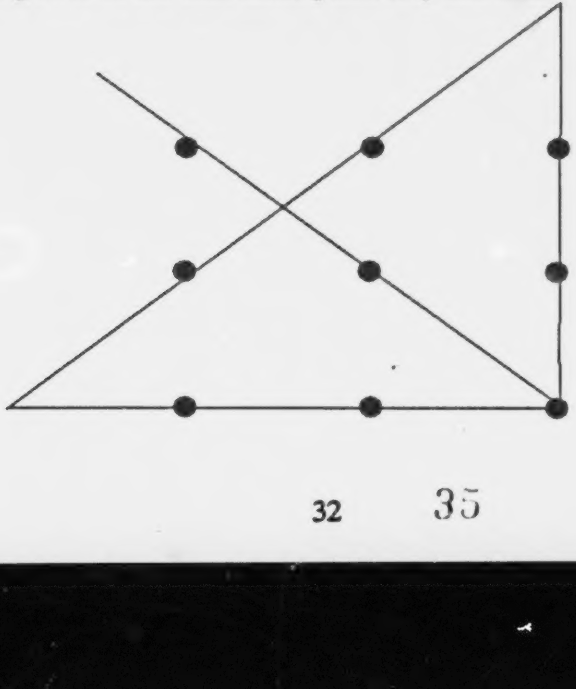
We had a vivid experience of this in the very first module. Organized to help the bakers think about the tacit assumption they use which inhibit problem solving, we presented them with the classic "nine-dot" problem presented below.

Instructions

Without lifting your pencil from the paper, connect all nine dots by drawing four straight lines.



Predictably, none of the operators could solve the problem. The solution's key, as the next insert shows, is to go outside the dots. But almost all people, upon confronting this problem, assume without reason that they are not allowed to. The operators were quite surprised upon seeing the solution and were struck (even overwhelmed) by the power of the tacit assumption they had made.



One operator, reflecting on his own experiences, deepened the instructors' appreciation of the dilemmas this problem created. The operator noted that he had thought about moving his pencil outside the perimeter shaped by the nine dots but that, were he do so, "[he] would be cheating."

The term "cheating" is evocative. It suggests that to solve problems, one must take the *authority* of operating from out of one's own hunches and feelings. But to take such authority is to confront the authority of others, such as the management or other workers. Solving the problem, at least for this operator, meant grappling with the images he had of what the "bosses," e.g. the managers or the instructors, would permit. Similarly, as we have seen, we found that group processes played an important role in the brainstorming process. People's fear of looking stupid, silly, unproductive or naive shaped their ability to think freely.

Finally, when playing the game of "Twenty Questions" both the instructors and the participants experienced the power of group *structure* on problem solving. We asked participants to play the game by trying to guess, as a group, "the person, place, or thing" in the instructor's mind in less than 20 questions. A familiar parlour game, Twenty Questions highlights the salience of how one can search for an answer by efficiently "parsing" the known or relevant universe of possible causes into general and then specific categories. If a person inefficiently parses the relevant universe, he or she will fail to guess the "person, place, or thing" in less than 20 questions.

In the first round (the answer was "Cher"), the group had no structure and no system for asking questions, so different people blurted out different answers, using up valuable questions without building upon each other's insights. Indeed, at one point, one person in the group actually called out "Cher" but no one picked up on it. After debriefing their experience, and acknowledging that the "group didn't work well together" the group changed its way of working for the second round (the answer was the "Liberty Bell").

Asserting their wish to be more organized, they spontaneously created two roles: one person to lead the discussions, and one person to ask the questions. In effect, recognizing that questions were a scarce resource, they authorized only one person to ask them and authorized another to help them assess the meaning of any yes or no response. Their problem solving ability dramatically improved. It took them 17 answers to guess "Cher" and only ten to guess the "Liberty Bell."

Taking the Learner Role

Third, the instructors often felt that one fundamental consequence of the course was that its participants saw themselves in a new light as learners, as people who develop insights into their own ways of thinking. The message of the course was not simply its content, but more importantly that *operators can take up the role of learners* and not just be workers.

Two experiences, although admittedly subjective, stand out here as telling. As we have seen in the module on brainstorming, the operators after practicing on a nonwork and work problem saw how their experiences in each differed. In the first, they felt relatively spontaneous and free, in the second inhibited. Steve, a baker, seemed particularly struck by this difference because, as he noted, the work problem was something he should know about; it was "actually happening." He seemed to have learned something important, both about the context for problem solving and about himself, and after the session was over, he very spontaneously walked over to the lead instructor and shook his hand, as if to say "thank you for providing me with an opportunity for learning."

Similarly, in the beginning of the course, Terry, the supervisor, took up a skeptical pose about the course, as if to suggest that he didn't have much to learn and we did not have much to teach. But reviewing his own experience during the critique period of the brainstorming session, he strongly affirmed the course by noting that its purpose seemed to be to "help us expand our thinking." Thus like Steve he deepened his relationship to the course by appreciating the process of learning itself, by taking the opportunity to be a learner.

In Sum: Three Broad Hypotheses

Our pilot training program at Cookie-Foods raised three broad hypotheses about training operators in some of the classic problem solving skills and methodologies.

1. Such training programs, when they are successful, convert the tacit into the explicit by helping workers think systematically about cause and effect relationships. By becoming aware of these skills, operators can overcome the inhibitions to perception and thinking imposed by relying primarily on their senses and their accumulated experience. Their thinking expands.

2. Such training programs, when they are successful, illuminate both the implicit and explicit group context which shapes a worker's ability to solve problems. In particular, a worker will be a more or less effective problem solver to the degree which he or feels *authorized* to think, to detect variations and propose solutions. Where peer pressure or supervisory pressure delimits the sense of authority, the worker will not be able to learn, much less use problem solving methodologies. This suggests, moreover, that when training programs ignore the group context and focus only on the individual participant's skills (as is done, for example, when learning is measured on an individual basis, before and after the training program), they can teach skills that can be *deployed in the classroom but that can't be implemented in the workplace*. Similarly, when training programs implicitly deauthorize workers (e.g., "off-the-shelf" programs that ignore the workers' specific context), or when the programs treat the workers as "beginners" who have no experience of their own, they actually inhibit the ability of the workers to both learn and apply problem solving methodologies.

3. Such training programs, when they are successful, help workers not only develop new skills, but see themselves as learners. These programs open the workers up to the pleasure of gaining insights and of learning from experience. This suggests, moreover, that when the training program eschews designs that provide opportunities for learning from experience, the worker, relying too much on the trainer's authority, can take up the role of *student* who learns from other people's experience, but not of *learner*, who learns from his own experience as well others'.

The Broader Context: Training and Organizational Development

While this pilot course was stimulated partly by the ambiguous impacts of the SPC program, we suspect that, as of this writing, it has had largely an indirect effect on the quality of workers' participation in problem solving in the factory, on their use of SPC, and on their collaboration with managers to improve factory function. The process of organizational development, particularly when it is shaped by conflicting interest and management ambivalence, is always a multifaceted one, so that any single effort -- a task force, a training program, a successful effort to correct a machine or balance a line -- has an effect only insofar as it contributes to the development of a new climate or culture for working and managing.

We believe the course supported Jeff Berg's efforts and helped a few supervisors understand the potential of improving worker skills and responsibility. But absent other reinforcing processes, its impacts might be minimal, reflected largely in the personal learning of the participants.

The instructional staff experienced some of these dilemmas toward the close of the course. Hoping to end with the application of problem solving methodologies to "real" problems in the bakery, they were left with simply helping the workers develop some initial problem maps for assessing why a particular cracker was burned when it came out of the oven. The logistics of ending the course with an actual problem solving effort required more instructor and supervisory time than was available. But it also became clear that the concept of problem solving developed in the course, the systematic review of data, and the testing of alternative hypotheses did not sensibly match *the actual roles that operators took daily.*

As we have seen, operators are problem solvers, but they do it on the fly, adjusting and tuning a line until the product comes out right. Their knowledge is tacit; it is not recorded anywhere and can be taught only through an informal apprenticeship process. To apply the explicit or rational methodologies of problem solving, managers would have to sanction new roles for operators through which they could step back from their front line roles and collaborate with industrial engineers to link their feel for the process to the former's data and suggestive correlations. They would have to become active participants in the engineers' problem solving process.

Under these conditions, their ability to think scientifically, to understand the interplay of divergent and convergent thinking, would be of great value. But as we have already seen, the SPC efforts, initiated by corporate and supported by its process-engineering group had not been linked into the different plants' way of working. It was still an add-on. Indeed, shortly after the training program's completion, Cookie-Foods, Inc. faced large production pressures due to the success of one its cookie lines. Jeff Berg committed to increasing worker participation in operating decisions, and spent a month of his time simply hiring new operators. Training and development activities compete for management's time and attention. Thus lacking opportunities to link training to changing roles and relationships, workers will rely on their day-by-day tacit approach when solving problems.

We experienced this poignantly at the very end of the course. While others enjoyed doing a problem map as a first step for examining a real problem in the bakery, an old hand with an Irish brogue, who had once expressed great skepticism about SPC, blurted out, "I didn't get nothing from this [exercise]." His frustration was evident. Regarding himself as the expert baker that he was, he simply could not relate to the problem map -- it didn't fit with the way in which he thought and acted on the factory floor. While he enjoyed the course, the application exercise highlighted the gaps he felt between himself and the course, and between himself and all of "modern management."

In sum, the training program had an indirect effect. It supported the slow and sometimes contradictory evolution of a new work culture. But lacking as it did a direct connection to new worker roles, it could only have a limited impact on how workers viewed and practiced problem solving. Training helps establish an orientation, but the energy to power the system, to get it to move, must come from other efforts. The sail turned into the wind, helps direct the boat, but only when the wind is blowing. To go from the tacit to the explicit, from the sensory level to the abstract, requires more than a training program. It depends instead on the transformation of roles and relationships on the factory floor.

Problem Solving as a Process of Generating ALTERNATIVES

Objective

To teach that generating many alternatives, even unusual, "way out" ones, is useful in problem solving. To practice generating alternatives using brainstorming techniques.

Allow time for discussion and evaluation at the end of the session.

Plan

1. Pass out the one page summary of work accomplished during the previous session, and review the points covered. In this session we will move on to another facet of successful brainstorming in which you force yourself to think in many directions about how many "might be's" it "could be."

2. Introduce the idea that it is useful to open up possibilities, including those which may at first seem implausible. Discuss brainstorming techniques:

   a. Any idea is welcomed, and judgment waived until the brainstorming session has ended.

   b. The more ideas the better. You never know what sort of idea may spark creative thinking on the part of other members of the group.

   c. Piggyback one idea upon another. Welcome combinations of ideas and additions to existing suggestions. It's amazing what kinds of relationships come up that can be useful later when making final decisions.

As the facilitator of this discussion, keep it moving. Make it clear that while brainstorming there is no correct or fully complete answer. Anything goes. Watch out for those who try to shut down the discussion by:

- pushing an idea they think is the one and only best idea for a variety of logically correct reasons;
- monopolizing the conversation
- continually suggesting reasons why an idea is useful, but "you have not considered ...." Or, "it will never work because ...."

3. Try the "Traffic Jam" exercise. Brainstorm with the entire group around the possible causes of a traffic jam. Introduce the traffic jam by creating a scenario for it. Record the ideas suggested on a flip chart. Remember to discuss assumptions as they are made.

4. Try the "Power Is Out" exercise. Brainstorm around the possible causes of losing electrical power in your house. Could try this one in small groups, with one person recording ideas and assumptions behind those ideas as they emerge (on a flip chart). Bring the group back together and discuss similarities and differences in ideas generated and assumptions made.

5. Move to an example from work life. If, for example, a product appears burnt as it comes out of the oven, how many possible explanations could there be. In-

gredients, dough, heat, weight, moisture, etc. - each contain numerous possible sources of error. This notion of container and contained, general and particular, will be discussed in the next section using an idea tree. Record ideas on a flip chart.

At this point there are two options for steps #6 and #7:

6. We can think of a problem as a room which can be entered through many doorways. Each one gives a different view of the room (problem). We can thus generate alternatives that are often overlooked by entering the problem from more than one of these doorways.

   From the time we are children, we are taught to solve problems by starting at the beginning and working through a sequence of steps until we reach the end. The choice of where to begin or where to "enter" a problem is often taken for granted, and yet it makes a critical difference in the solutions we are likely to produce. By not considering alternative entry points, we may preclude certain patterns or solutions from ever being perceived.

   Similarly, we often focus most or all of our attention on a particular aspect of a problem without considering alternative areas to which our attention might be directed.

   The most common entry points for solving problems are:

   1. The beginning of a sequence or flow of activities.
   2. The one part of the system where the problem shows up.
   3. The one part of the system over which we have the most control.
   4. The part of the system about which we have the most knowledge.

None of the above entry points is guaranteed to lead to a satisfactory solution, and many times the first entry point we pick won't lead us where we want to go. It is important to explore alternative choices of entry point because a different entry point can lead to a different chain of thoughts and a new way of restructuring a problem.

Step 1: Identify a problem or situation and, if appropriate, draw a flow diagram showing the various stages, inputs and outputs.

Step 2: List several possible entry points that could be used in considering the problem

Step 3: Assign each entry point to a small group. Have each group explore how using this entry point will lead to particular alternatives or ways of attacking the problem.

Example:

How to solve the problem of prison overcrowding.

Possible Entry Points:

The problem is there aren't enough prisons.

The problem is judges who sentence people to prisons who don't belong there.

The problem is a lack of community alternatives.

The problem is too many people coming back after they've been released.

7. Try a worklife example.

Crackers
Count per pound variation across the band creates high % B&R, excess/inconsistent carton weights, re-work and decreased yields. Currently costing the bakery approximately $xx/year (B&R and excess package weights).

Cookies
High breakage created at loader -- by off-center alignment of basecake, inconsistent stack height of basecake and inconsistent bake across the band. This generates high % B&R, downtime, and re-work.

OR

6. "Twenty Questions" exercise: One person thinks of some person, place, or thing. Other participants can ask "yes" or "no" questions in order to discover what that person is thinking of. We are using the "Twenty Questions" game because each question asked chooses one alternative of questioning, and at the same time rejects others. The game also enables us to move from general alternatives to more specific ones, to eliminate alternatives that are not useful, and to describe our own assumptions. In many troubleshooting situations there may be more than one variable to identify, but "Twenty Questions" offers a useful starting point.

7. Using an example from worklife, construct a knowledge tree. Use an overhead to draw a tree and review the possibilities recorded on the flip chart for the "Traffic Jam." Revisit the "Burnt Product" example. Then break into small groups and work on the "Burnt Product" example, this time constructing knowledge trees to break up facts into general categories and particular facts. (You may, or many not, want to post the flip chart record of possible reasons for the burnt product.) Each group can use a flip chart to draw their own trees.

   A more complex worklife problem could be introduced as well. For example, a cracker comes through the oven and the weight and moisture are within range, but the color is out of range on the Agtron. How can we use the troubleshooting techniques to solve the problem?

   1. Record assumptions

   2. Generate alternatives.

Materials

- Flip chart and markers for each group
- Pencils and paper

Notes on Cookie-Foods Pilot/ Module #3: Generating Alternatives

1. Review last week's summary sheet. First group made the following comments re: group process (2nd group did not have anything to say about the summary sheet):
    - Two people mentioned that group work is more like play than individual work.
    - Enjoyed the emphasis on hands-on experience
    - More reinforcement when working in groups
    - If the group is too big, it's often ineffective
    - A supervisor in the bake shop ran groups a while ago, but it didn't seem to accomplish anything. The company didn't make any real commitment to the idea, it was completely up to this particular supervisor. He did it on his own.
    - Hirschhorn mentioned that one of our goals is to develop tools for group work, to develop a shared language and method for problem solving.
    - Groups are good for building one idea on another also.
2. Introduction of brainstorming using the research done on "Green light" groups of WW II cockpit crews vs. "Red light" groups.

    First group said this reminded them of (1) the Andes plane crash and survival of some members of the group; (2) a fishing trip where one person is the leader and forced to make all the decisions, and this is not healthy for the group. This brought up the notion of the role of followers, is it passive or active?

    Hirschhorn mentioned (1st group) that "green light" groups had a method of just getting started, something that the first group had thought was a good tactic when problem solving.

    Discussed the rules of brainstorming, i.e., no evaluation of others' ideas and no censorship of one's own ideas; build ideas on other ideas offered to the group.

Evaluative Exercise

1st Group. Then tried an exercise that did not follow these rules, where Hirschhorn was evaluative and rejected ideas as useless, etc. First try did not work well. Topic:

How to get diet conscious people to eat more cookies. Then tried it again, with topic: Burnt product. Responses to how it felt to have ideas instantly evaluated included:

- Would have been tough if you meant it.
- In this kind of setting, the problem usually gets blamed on someone.

Then discussed the difficult process of separating *solving* from *blaming*, especially when the stakes are high, e.g., while at work when your expertise is on the line.

2nd Group. Topic: Absenteeism and lateness problem. Responses to instant criticism of ideas included:

- climate of fear created, shooting people down
- created silence in the room
- the sense of urgency often shuts people's thinking down
- climate of antagonism created between supervisor and worker, which then has people fighting with each other as well.

3. "Traffic Jam" Exercise (See list of responses. This done with the whole group)

1st group. Responses to how it felt-

2nd group. Responses to how it felt-

- Some ideas feel silly or repetitious, and it's hard to get past that feeling
- Everyone was talking, they were on a roll. It was difficult to get into the conversation.
- Everyone else seems to be productive. What's my role here if I can't seem to think of anything?

We then mentioned that the key indicator (building on the notion of play earlier in the first group) is: Are you having fun with the problem? Having fun is a sign of a creative group. It's ok to have fun while brainstorming. In fact, having fun with the problem is often one of the more difficult things to do. We're not used to it.

We noted that there was some building on ideas, especially around the topics of "things dumped in the street" and on word association.

We also mentioned that it takes a while often to get at the simple, common ideas or causes. Sometimes you have to go through some of the "silly" ideas to get to those we take for granted because they're so obvious.

4. "Power is Out" Exercise (done in small groups - see lists)

1st group. Responses to how it felt-

We mentioned that without recording, ideas go nowhere. There is no systematic way of getting a group's ideas down, and no organizational memory.

The obvious "bill not paid" cause came out late in the list. Both groups moved from direct, local causes (a wire broken, for example) to more indirect and then "wild" causes such as sabotage, etc.

2nd group. Responses to how it felt-

Hirschhorn mentioned that a lot of work was done on the wiring, but not as much on the social side. This in response to one person's mention that one of the responses did not address the problem because it was on "the human side."

We mentioned that sometimes we stay with a set of ideas until they are exhausted, e.g., all sorts of technical reasons, and only then can we get past that "set" of ideas and move on to the next. We get localized on one "seam" of a coal mine. The difficult part is to stick with it past the point where we think we've thought of "everything."

- Sometimes it takes a silly idea to get started on the next seam of ideas.
- It's difficult not to evaluate, e.g., "Turning the lights out to avoid someone." How does that fit in?
- I almost didn't say, "______," thinking that it was stupid.

Hirschhorn then brought up the ideas of brainstorming as a "structured conversation," and of "divergent" and "convergent" thinking. [In the 1st group this point was made after the work life example. See discussion under that heading.]

5. Work Related Exercise - The Cracker Example (see lists)

1st group. Some responses to how it felt-

- This is harder than the traffic jam or power is out examples because it, i.e., the problem, is actually happening here in the plant. [Hirschhorn mentioned that when the stakes for you are higher, it is less of a game, and the problem becomes a real one.]
- There was lots of thinking and holding back before deciding to include an idea.
- Brainstorming moved slower, but we thought more. It was not as spontaneous.
- We were drawing from past experiences
- We need to blurt it out and get it up there (on the lists). Evaluate it later.
- I think it was less play. [The issue here is: How can one learn to play with that which is serious? The intersection of work and play in brainstorming may be a fruitful area of research. It certainly dovetails with O'Connor's work.]
- Just throw out an idea. Someone else may be able to build on it.

We pointed out that there were quite a few technical and technological causes listed, but few social causes, e.g., faulty communication between the baker and the machine operator. Hirschhorn then used this to introduce the ideas of "convergent" and "divergent" thinking.

2nd group. In comparing the lists we noted the same point as above, i.e., the emphasis on technology and not on the social side of the operation.

- There are differences when you work a problem close to home.
- It was easier to work because [the situation] happens every day.
- It is more interesting [than traffic jam or power is out] and it's true.

Hirschhorn tried to introduce the point about when there's more at stake for you, you often tend to clam up. This did not work too well with this group. They saw the problem as easier to work with, but were not able to see themselves fixed on the technical side, and concerned about how their peers, and in some cases superiors, would react to a "stupid" idea. A couple of responses approached this notion, though:

- This example cuts down on imaginative responses (to them because they were "really" working).
- There was some nervousness and joking around, e.g., about the "bad operator." [Interesting to note that the joking occurred at the introduction of *human* error into an otherwise technical/technological discussion.]

We asked the 2nd group to find an opportunity to brainstorm during the week with 2 or 3 others around a topic of their choosing. [We did not ask the 1st group to do this. We should be more consistent with these assignments, i.e., plan them ahead.]

6. Evaluation

1st group.

- Cracker example was hard for me. I know my job pretty well, and I stopped to think because I didn't want to look stupid.
- There's a lot of experience here in this room. Looking at this list, we repeat ourselves a lot. There's a problem of direction. Too many foremen do the brainstorming themselves and the follow-through themselves rather than giving direction about how the problem can be solved. There is not enough learning from experience.
- We haven't been pulled together to work on a problem.
- When there's a problem everyone blames someone else [instead of attacking the problem directly as a group].
- Often solutions work fine for the moment, but then people don't continue to work on the problem and it recurs again.
- Some things are technical; others we can do ourselves.
- We can create lists, but how do we use this information and organize it.

Critique:

- Supervision should be here too.
- Often we don't make decisions because, "If I don't make the decision I won't get the blame, the company will."
- These were realistic exercises. We do this ourselves individually [but rarely as a group and we rarely record our ideas].
- We sometimes forget the most obvious thing. These exercises get at these.
- Every change listed affects the baker. No matter where the change is located (ingredients, mixing, wherever) he has to make an adjustment.
- Social problems often occur in the interaction between two groups, e.g., baking and packing. [Hirschhorn introduced the idea of problems occurring on the boundary between groups where no one is responsible for the activity. People are responsible for their jobs, but rarely is someone responsible for the boundary between two kinds of activity, e.g., baking and mixing.]

2nd group.

- These exercises make everybody think as a group.
- It is often useful to have someone in the group who is not familiar with the problem in order to get that outside perspective. We are often too close to the problem to see logical causes.
- The push with the entire pilot program is to expand your thinking.

Brainstorming Sample

Power Out

no power
fuse
overload
blackout
short brake
fire
lighting
animal on wire
wet tree leaves
wind storm
ice storm
tree falling
car hitting pole
nuclear meltdown
war
flood
failure to pay bills
strike at power plant

Burned Cookies

roller
ingredients
mix
timing
build up on roll
R.P.M.
no flour
soft dough
tight dough
adjustments
crowding on rollers
old dough
band speed
burners
oil
too much salt
not enough salt
scales not working
too much meal in dough
temperature
turn over in mixing
foreign material in dough
too much heat
not enough heat
fan not working
pressure gauge roll
weights
water content

Recap: May 3, 1989 (Summary Sheet Given to Participants)

Purpose

To learn that generating alternatives, even "way out" ones, can be very useful when problem solving. To practice generating alternatives using brainstorming techniques.

The Idea

We introduced brainstorming through a discussion of "green light" and "red light" World War II cockpit crews. "Green light" crews were found to have a higher survival rate after a crash, and this was linked to their ability to flexibly generate a wide variety of possible solutions to a problem, regardless of how crazy some of them might seem.

We discussed the rules of brainstorming

1. No evaluation of others' ideas, and no censorship of your own ideas.
2. Try building on other people's ideas.

Exercises

1. The "Traffic Jam" exercise:
    - Some ideas felt silly or repetitious, and it's hard to get past that feeling.
    - Everyone else seems to be productive. What's my role here if I can't seem to think of anything to say?
    - It takes a while to get at the simple ideas or causes. Sometimes you have to go through some of the "silly" ideas to get to the ones we take for granted because they're so obvious.
2. The "Power Is Out" exercise:
    - Without recording, there is no way to remember the group's ideas.
    - An obvious reason, like "The bill was not paid" came out quite late on the list.
    - Both groups moved from direct, local cases (like "A wire is broken") to more indirect or wild cases (like "Sabotage").
    - It seems like we have to stick with one "seam" of ideas, like the seam in a coal mine, until it is exhausted. Only then will the next "seam" appear to us. The trick is to stick with it past the point where we think we've thought of everything.
    - Sometimes it takes a silly idea to get started on the next "seam" of ideas.
    - It's difficult not to evaluate and think that your own or another person's idea is stupid.

3. "Cracker Line" exercise:

- This is harder than the traffic jam exercise because it's actually happening in the plant.
- It is less of a game when the problem is a real one.
- There was some nervousness and joking around about the "bad operator."
- There were a lot of technical causes listed, but only a few human causes.
- I know my job pretty well, and I stopped to think because I didn't want to look stupid.
- Supervisors should be here too.
- Often we don't make decisions because, "If I don't make the decision I won't get the blame, the company will."
- We do this individually a lot, but rarely as a group. These exercises push you to think as a group.
- Every change listed affects the baker. No matter where that change is made, the baker has to make an adjustment.
- It's useful to have someone in the group who is unfamiliar with the problem. We are often too close to it to see it clearly.

II. Steps Toward a Project Culture

Circuit, Inc: A Walking Tour

A walking tour of the Circuit, Inc. factory in a medium size northeastern plant highlights its innovative character. No wall divides office from factory work proper. Instead, a yellow line painted on the floor (to signify where electrostatic charges can interfere with production) separates the two areas. By stepping over the line from the factory, the visitor enters a warren of cubicles, staff offices and meeting spaces for factory teams. The design is "office open," with partitions separating desks. The meeting spaces squeezed between the desks are equipped with large conference tables, white boards, and flip charts. There is an easy flow of people between the two areas, and every factory operator has a cubicle equipped with a computer. The visual distinctions between factory and office have been eliminated.

Opened in 1983 and staffed by about 150 operators and 50 support personnel, the plant produces memory storage devices for computers using both an older technology of inserting components into wired circuit boards and a newer technology which mounts components. The latter is automated; the former is based on both automated and manual procedures.

Touring the plant, the visitor walks nimbly between stations and machines; machine layout is orderly but tight. In fact, the plant has achieved levels of production using half the average space of similar plants elsewhere. Though the factory assembles circuits, the visitor at first glance has no sense of a linear flow of material through a multi-stage process -- partly because much assembly takes place within machines, and partly because the factory itself is organized into three relatively autonomous product lines. Watching the operators work, the visitor sees that the majority monitor, maintain or calibrate machines. Some, however, fix faulty boards, while others do the old and more familiar tasks of stuffing them.

The plant is designed as a "sociotechnical system." This means that the operator teams, committed to the production of one of the three product lines, are self managing. A business manager is ultimately responsible for each of the lines, but teams are expected to manage most of the daily work themselves. Although operators are paid by the hour, their hourly rate rises as they master four basic skills: managing the production process from front end to back, using computers and the plant's information system, facilitating the team process, and mastering basic materials handling and purchasing tasks. In addition, most operators are capable of performing basic preventive maintenance activities (greasing, inspection, cleaning, etc.) while a few on each team are skilled in diagnosing machine dysfunctions. All experienced operators are "floor certified" -- i.e., while some may work with particular machines, they are capable of performing all the tasks required to produce a product. The workforce is "multi-skilled."

As a sociotechnical system the plant has peformed more effectively then many traditionally organized circuit manufacturing plants. One study of the plant's functioning highlights several of its key accomplishments: it has a achieved a 40% reduction in the standard time required to build circuit modules; it has a one-day cycle time, so that parts move from recieving to shipping in a day; its Just-in-Time inventory system has eliminated buffers; its "inventory and capital turns " (the ratio of sales to assets) are very high; and it has reduced scrap by 50% since it began prodcution.

Managements' regard for its workers has been central here. Workers were involved in the planning and designing activities that gave shape to the plants' social and technical system, all team members participated in a week long training program on the challenges of team dynamics and the pay for learning systems gave every team member to become floor certified in all the basic skills. The teams themselves have the opportunity and resources to manage their daily affairs without the intrusion of the business managers. All team members have small desks on the other side of the yellow line and each team has its own meeting space, squeezed in among the warren of the open-plan offices or cubbies that make up the desk or office side of the facility. Finally, operators participate actively in the development of the plant and in the implementation of new technology. Thus for example, in introducing the new surface-mount technology (to be discussed shortly) operators participated in analyzing its variances, designing a prototype line and building the intial circuit modules. Operators also participated on a task force examining images of the "factory of the future."

Finally, as a plant community with its roots in the traditions and practices of the sociotechnical system, Circuit's personnel see the plant as an open system. By using the company's computer network, operators work with engineers from other parts of the country to design new memory/storage products and actively collaborate with suppliers and vendors to insure that the materials and machines they supply are appropriate. Moreover, plant personnel play an important role in helping company personnel throughout the country keep abreast of new technology.

Learning and Training: New Challenges

Sociotechnical design theory suggests that the problem of training can be partly resolved by integrating working and learning. In such factories, workers are paid more as they master more skills. Thus at Circuit, Inc., every worker has to master the basic skills in each of the four skills blocks to obtain the basic rate and become "floor certified." In addition, they can then choose to specialize in one of the four to increase their pay. For example, in the maintenance skill block, every operator can do basic preventive maintenance tasks but only a minority can repair machines.

Such a system provides both incentives to learn and a stable system for compensation; in other words, it reliably links learning, effort, and pay. But such a system is inadequate if the technology changes significantly. Then operators have to re-learn basic skills and the plant's management cannot simply rely on the rate at which operators individually choose to master both basic and complex skills. While the sociotechnical system design does integrate working and learning, it cannot substitute for formal training efforts. Indeed, at the time of this study, the human resources staff had just completed a "reskilling" survey and study based on the feeling that the factory's training efforts had to become more systematic and future oriented. Let us examine the context that shapes these new challenges to training.

The New Technology

Circuit, Inc. is going through technical and social system changes which challenge its current skill mix and puts greater pressure on the training system. Its processes are becoming more automated as plant management purchases "surface-mount" machines. In the past, automated and hand assembly were based on "through-hole technology" in which machines and people basically stuffed or pushed circuit materials into the circuit board. Standing at an automated assembly machine based on through-hole technology, one sees spools of materials, like beads strung on a necklace, unwinding into a machine. But in surface-mount, the smaller and mor closely packed parts are automatically glued to the surface. While operators use a vision system to see the parts, defects are hard to spot and mistakes happen much more quickly. Since correction is difficult, machine set-up becomes more important and operators control errors by spotting trends or deviations in the process rather than by correcting a single error. The operators' relationship to the machine system becomes more abstract based on data and planning rather than on observation and direct intervention.

But just as Circuit, Inc. is investing in these new machines, it is also going through a change in its relationship to the marketplace. While it has always been an important production facility in the corporate system, it is increasingly functioning as a prototyping factory producing storage devices in low volume and then handing them off to other factories in the company when the production bugs are worked out. The factory is organized increasingly as a project system where operators and engineers work together on temporary rather than permanent teams, and disrupt a steady state flow to improve a process rather than stabilize a steady state to simply control it. The skill block system which was developed to fit with a prior technology is no longer adequate.

The Challenge to Training

Training as a system consequently faces significant challenges. A training-learning system which once worked very effectively must now be redesigned. One human resource professional responsible for training noted, "Training is missing an agenda. I think it has to be an ongoing process. We once thought of it as a point solution, but now we need an ongoing strategy." Similarly, another person argued that past training programs had been unfocused. "This past year we offered a lot of courses -- people were bombarded with courses, and I think what we have learned is that people are overwhelmed with this kind of training. We need to specify a systems approach, and organize training in relation to our products." Indeed, considering the significant changes it faces, two human resources professionals estimate, on the basis of a training plan, that each operator will need 4.2 hours of formal training per week over the next two years, or the equivalent of about four college courses.

But how can we conceptualize the nature of training? What are the new skills that operators need? What image or conception of the operator can Circuit, Inc. use to define the core social and technical skills its workforce must master.

To explore this question we want to examine the context within which skills are both exercised and developed. Based on interviews with operators, managers and human resource professionals, and two site visits, our argument is divided into four parts. First, we examine the plant's basic tasks and its corollary linkages to its external environment. Second, we examine how the new technologies shape its ability to accomplish its basic tasks. Third, we examine how these new technologies combined with the consequent new tasks change the nature of the social relationships and link operators to their work. Finally, we examine how these marketplace, technical and social changes create a new conception (what we call a "core image") of operator skills.

In short, to place training in context, we first examine the emerging key tasks faced by the plant as a whole, we link these tasks to key operator skills, and we link these skills in turn to training's emerging agenda. We argue that the plant's project culture and the demands of surface-mount technology *stress the plant's basic team and pay-for-knowledge systems.* While semi-autonomous teams have been central to its functioning, the new demands for working and learning may lead the plant community beyond teams.

The Context for Training

Basic Tasks and Key Linkages

To understand the challenges to training at Circuit, Inc., it is important to understand its environment. To explore key relationships, the company must manage to accomplish its mission. Ultimately, skills and tasks are linked to an organization's goals and objectives. For example, plants producing a low value-added commodity with known features and a stable technology require different skills than plants producing a high value-added product with a changing technology. Circuit, Inc. sells primarily to internal customers within the parent corporation, supplying the computer and computing device producers with a range of storage disks. But this internal environment is a complex and changing one, and as the marketplace for computers as a whole changes, Circuit, Inc.'s relationships to its internal marketplace change as well.

Three Relationships

The interviews suggested that Circuit, Inc. must manage three boundaries, that is, it has three different kinds of relationships to its marketplace: the relationships between Circuit, Inc. and its internal customers; the relationship between Circuit, Inc. and the company's overall Storage products division when the plant functions as a ramp-up facility for Storage; and the relationships between Circuit, Inc. and the wider world of electronics technologies and storage devices. As the following table suggests, each relationship has a distinctive task, outcome, key measure of success, and plant culture. For example, the Circuit Inc./customer relationship highlights the plant's role as a reliable supplier of high quality storage products; the Circuit Inc./Storage division relationship highlights the plant's role in bringing new products to market; and the last relationship highlights the role of the plant in helping to link the Storage division to changes in core technologies. In other words, the first relationship highlights the plant's role as a *producer,* the second as a *product developer*, and the third as a *knowledge broker.*

RELATIONSHIPS

	Circuit, Inc./ Customers	Circuit, Inc./ Storage	Circuit, Inc./ Technologies
Task	Produce	Develop products	Broker knowledge
Outcome Measure	Volume	Time to market	Diffusion
Key Measure of Success	Reliability and cost	Schedule and slope of learning curve	Rate of knowledge diffusion
Culture of Work	Product	Project	R&D
Culture of Time	Steady	Cyclic (steady and then breakthrough)	Logistic

All three relationships are important to Circuit's mission. None can be ignored, and each affects the others. But the interviews suggest that Circuit, Inc. *has stabilized the first relationship, is learning to manage the second, and is beginning to develop the third.*

Discussing the first relationship, one person noted, "We have built good relationships with our customers. The plant has credibility; we are preferred by them. In the beginning they saw us as experimental, but we have made the transition." Similarly, the plant is already functioning as a ramp-up facility. One person estimated that 30% of its effort is committed to low volume production lines, and another argued that the plant will increasingly take up the "consulting-engineering role for other products." Finally, two people noted that Circuit, Inc. should play an increasingly important role in linking the Storage/memory device division to relevant changes in electronics technology. "I see us taking up a larger role in the electronics arena. We have to take on a leadership role, go beyond just prototyping, and become the critical interface to these technologies for other parts of the company. A lot of people at the division level do not understand electronics."

But as the table suggests, these developmental shifts from the first to the third relationship pose new tasks, outcomes, key measures of successes, and cultures of work and time. This suggests, moreover, that *the skills required to work within and manage each relationship differ as well.* Thus for example an operator working in the first context must focus on product reliability and machine down-time, while an operator in the second must focus increasingly on issues of "producibility" while learning to learn from the experience of "breaking in" new products. In the first case the operator must be able to control the machine, inspect the product and perform preventive maintenance. In the second, the operator must contribute to developing the machine process while communicating his or her experience to other team members and engineers. As one person noted, "[The operators] need to get engineering prototypes back to engineers faster. They need to feed the engineers more accurate information on producibility so that we can reduce maturation time." Reliability remains important, of course, but product development means that plant personnel must acquire new project development and project management skills while maintaining the old production ones.

Surface-Mount Technology

The new surface-mount technology both supports this shift to the second and third relationships while also reshaping the skill set required to work in the plant. Surface-mount can support a "project culture" for two complementary reasons. First, insofar as software controls the mounting and glueing process, it is easier to recalibrate the machines to manufacture new products. Set-up, while more technically complex, becomes potentially less costly. Second, as set-up and changeover costs fall, low volume production becomes more economical.

But in supporting low volume production and a potentially less costly changeover process, surface-mount technology also poses new challenges to the skills of operators. Because manual board insertion becomes less important, the operators primarily control a process rather than make a board, and intervene where the controls themselves fail to mount microscopic parts in the correct way. As one person said, "These are machines that are self-diagnosing and there is built-in vision. If you put in fine pitched parts it will make a correction to the placement. But someone will have to gather information to see if the placements are correct." In others words, the operators "control the controls."

Many of the people interviewed highlighted the challenge to skill and skill development that this new technology poses. The new surface-mount technology, one person said, was "a much less forgiving technology" than the older through-hole technology. The features of *time, interdependence* and *transparency* seem particular important here. For example, one person said, "In surface-mount you need to figure out what is going on in a very short amount of time. You make mistakes a lot faster, and there is an urgency of getting it resolved." Similarly, going on to describe the control process, the person said, "There is a greater interdependence between the people doing the work," so that the place where a variance is observed may not be where it occurs. By contrast, "In tracking through-hole, if a component is not in its hole you can assume that something is wrong with the placement equipment." In tracking variances, the process is less transparent. "If the soldering is off in the surface-mount, it is not obvious where the variance comes from. The components are smaller and more dense. You can no longer see the cracked capacitor." Finally, because surface-mount is less forgiving and variances have broader and less predictable effects, set-up planning becomes more important. "We have to be conscious of doing it right the first time," one person argued. "In through-hole we could fix it after we found a mistake, but with surface-mount we need to be right from the start." This means that an operator can rely less on feedback from local problems and more on "feed-forward" or on predictions about the state of the process based on a systems understanding of the technology.

Social System

These complementary changes in context and technology also reshape the texture of the plant's social system. Rooted in sociotechnical theory and practice, the plant was designed around production teams, each controlling a particular process and responsible for a particular product. But as it functions increasingly as a ramp-up facility and brokers new knowledge from and to its environment, *its future effectiveness is linked increasingly to the ways in which it designs and manages "intergroup" and "plant as a whole" (or "large group") processes*. Operators must interface more intensively with engineers and support personnel to develop a product. Moreover, as the plant takes up new technologies which cut across the product lines, it must rely on "boards" or standing committees which look at problems and issues that cut across the teams, such as new maintenance procedures or quality problems. The following table examines these differences.

SOCIOTECHNICAL ELEMENTS

Basic Tasks *Infrastructure*	**Produce**	**Develop**	**Broker**
Social System	Small Group (team)	Intergroup (project)	Large group (plant as a whole)
Technologies	Machine stations	Design tools	Dissemination vehicles

As the table suggests, when the factory simply produces a steady stream of stable products, the core technical system is represented by the machinery and the core social system by the team. But when the factory breaks in new products, design tools such as CAD/CAM technologies become the new technology, while the project team composed of operators, engineers and support people becomes the foundation of the new social system.

Indeed, several people noted that in a ramp-up plant, engineers as well must take up new and increasingly important social system roles in facilitating the project process. The linkages between operators and engineers must become more sophisticated. Engineers, as several argued, must become more adept at negotiation, presentation, communication, and coaching. "Our engineers," one person said, "need basic contracting and negotiating skills so that they have a clear understanding of what they are contracting for." Similarly, another person said, "There is a growing demand on the engineers to be coaching, teaching and presenting in the team environment. They have to get to feel that they are part of the team."

Finally, in a project culture, the more intense interface between operators and engineers is matched by a growing interdependence between operators and indirect labor. As operators manage parts of the project process – creating schedules, negotiating access to machinery and resources, working with vendors -- their work amplifies the ongoing work of the support employees in the different areas of purchasing, materials management, and finance. As one person said, "We are trying to develop more skills in our operating teams for support roles, such as materials, finance, and administration."

Stress on the Teams

There is some evidence that as the plant develops, and makes a transition from a social system based largely on stable product teams to one that is based on less stable project teams, the team system itself is stressed. Three examples are relevant here.

First, when the plant was originally designed it was built around three different teams, each with its own machinery for making memory devices. Their autonomy and integrity was supported by the fact that they had their own machines. But because surface-mount technology is much more expensive than the older through-hole technology, plant management plans to expand the single line it currently uses. This means that to insure full utilization, the three teams will have to share one line as they produce both their high-volume and their prototype products.

This plan has already created problems of inter-team coordination. In training operators to work the surface-mount machines, trainers, managers and operators faced problems of personnel balance among the team. As one person noted, "There has been a problem of sharing resources between teams. We thought we would take our best operators from the existing processes and put them into surface-mount. But when it came down to the point of giving up their best people, they didn't want to do it." Another recalled, "The teams have really resisted breaking up. We need to get closer to how we are going to organize surface-mount before we can go ahead."

Indeed, when the transition is complete and the teams share the same surface-mount line, they will lose the signposts of technical integrity that their separate systems gave them. One person noted, "When we provided each team with its own equipment, the utilization rate used to be 40-50%. But since the new equipment costs more, the teams will have to share it. This is a major change." Another person felt that as they lose their technical boundaries, the teams will face new social system challenges. "When you try to bring the three different cultures of the teams together, the social system will be way out of whack."

Moreover, the ongoing interaction and increasing interdependence between direct and indirect labor has stressed the boundary between these two groups and challenged the operating team's function as a home base for operators. Although they are formal members of operator teams, some operators see their future in indirect labor work and therefore no longer regard the team as the psychological "container" for their feelings and occupational identifications. One person observed, "Quite a number of operators want to get out of operations. A lot of people have been exposed to the other side; they want a career. Some have aspirations for OD, some love inventory processing. When you get a taste of the other side, a lot of people don't want to come back." Another person thought that "most of the operators want to get into the support area; they want to get away from building modules." As operators take up more indirect labor work, they may wish to be evaluated and acknowledged for their individual contributions. One operator regretted that she was not appraised by management, suggesting that as a member of a team she was actually lost in the crowd.

Finally, it is likely that as Circuit, Inc. enters a project and R&D culture, the links between the managers and teams will intensify. Managers who are currently taking an enabling or facilitating role want the teams to regulate their processes and solve their own problems. But if the technical and social change gradient intensifies, it is likely that managers will have to intervene more frequently as the team faces new technical challenges and new role relationships which it cannot solve alone. One manager, commenting on his relationships to team members, noted, "If you took me back to the time before surface-mount it was a rare time I came back into the team. But with surface-mount it was a new team. They had to understand what they had to do and how they had to do it." In others words, new situations re-engage the manager at the boundary of the team.

This more intense relationship between team members and the manager poses new challenges to the manager as well. In steady state sociotechnical systems, managers often face the problems of "abdication," of simply ignoring the teams and failing to link them to the enterprise as a whole. But in a changing or developmental system, the manager faces the problem of periodically supervising without simultaneously undermining the team's sense of its own competence. Indeed, there is good evidence that the rate of technological change at Circuit, Inc. will speed up. "We are already seeing the next level of technology beyond surface-mount, such as tab technology," noted one person. As the rate of technical change increases, the manager must actively help the team without creating undue dependency. This more complicated relationship between the manager and the team, and between two levels of authority, again reduces the team's salience as the primary psychological container for its members.

Interestingly, one person thought that the teams are providing *less* social cohesion than they had in the past. Reflecting on the way in which personnel often must "hold people's hands," this person felt that the "skill of nurturing" used to be in the teams but that seems to be less the case now. "The teams provided a lot more social outlets then," this person noted, "Can we get back to that now?"

All this does not mean that the team system will be disbanded or that teams perform no important integrating function. On the contrary, they continue to be central. But as the plant enters a project and R&D culture, the team system cannot do as much of the work of integration it had performed in the past. If it is not to be overstressed, it needs to be supported by emerging intergroup and large group designs.

Indeed, project teams which link operators with support personnel and engineers provide one such forum of social integration. In addition, plantwide groups have emerged to create plantwide roles for factory personnel. The boards or standing committees on technical issues link people through the plant to common technical concerns, while helping the plant stay abreast of broader technical changes. Similarly, the plant assembled a 17-person task force to assess the challenges that recent technical changes pose to organization and training. Such task forces provide forums or settings for people to take up plantwide roles rather than just team roles. The following table summarizes these challenges to the team based system.

Change In Context	Challenge to Teams
One surface-mount line	Team loses signposts of technical integrity
More rapid technical change	More interaction between managers and team
More interaction between indirect and direct jobs	Operators identify with white collar careers

Changes in the business context, technologies, and social system pressure shape an environment for skill formation and training. At Circuit, Inc., the changing business context links people to a project and R&D culture; the changing technology creates new process control tasks; and the changing social system configuration creates a need for interaction and communication at the intergroup and plantwide levels. Let us now see how these changes shape the process of skill formation and training.

Skill Formation and Training:
The Role, the Skill Base, and the Training Delivery System

As we have seen, people in the plant community want a focused and strategic training system. To understand the challenges they face, it is useful to first develop a *core image* of the emerging work that operators have to accomplish (both in its technical and social dimensions), then link this image to specific skills, and finally examine how different training vehicles may help operators master these skills.

The Concept of the Core Image

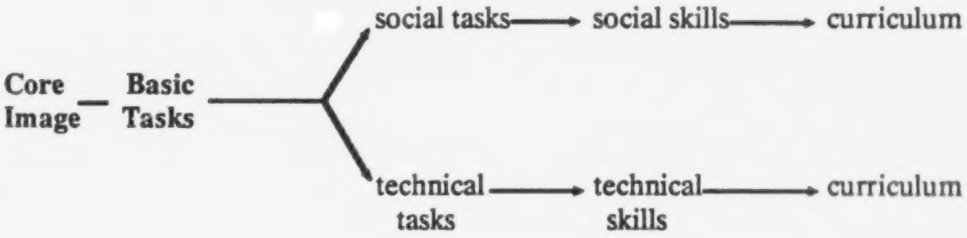
Human resources personnel are keenly aware that recent and prospective changes in the plant have placed great stresses on the training system. As we have seen, they estimate that operators must spend four hours in training per week over the next two years to keep up with the changing technology and changing task system. They estimate that such a training program would cost two and a quarter million dollars per year. Designing the prospective curriculum for such a training effort, they developed a large and wide ranging list of courses in the areas of manufacturing technology, human resources utilization, and business partnership skills (e.g., working with vendors). The following table provides a sample of some of the courses they list in each of these categories.

Manufacturing Technology	Manufacturing Operations	Human Resource	Business Partnership
Variance Analysis	Capacity planning	Management skills	Project negotiation
Statistical Process Control	Just In Time	Feedback training	Diffusion Strategies
Process Simulation	Shop floor scheduling		
Controller Maintenance	Problem solving		

This list, only a sample from the larger list developed by the human resources department, highlights the depth and breadth of the training challenge facing the plant. But for the purposes of this analysis, the list is too detailed. It is useful to construct a more general framework which both links the variety of course listings developed by the human resource department to a framework for thinking about training in a *range* of manufacturing settings.

To conceptualize this framework, one should first develop a core image of the future operator role. Such an image is based on a concept of the key tasks associated with the role, the skills required to perform these tasks, and the curriculum that can help build these skills. To give an analogy, the core image of the role associated with a "liberal arts education" is one in which a person, acting as the *responsible citizen*, performs the core tasks of critical thinking, writing and talking. In turn, such skills as doing research, arguing from premises to conclusions, and appreciating differing points of view are all associated with this role and its tasks.

Finally, in developing a core image of the future operator role in a factory, it is useful to base this image on the key *technical* and *social* tasks that the operator has to perform. The following diagram summarizes this conception.



The table beginning on the next page provides a picture of the emerging technical and social tasks and their associated skills that operators at Circuit, Inc. must perform. Clearly, it does not describe all their tasks and skills, but rather those basic tasks and skills that are emerging as a consequence of changes to the technical and social system.

EMERGING CORE TASKS AND SKILLS FOR THE OPERATOR

Technical

	Task	*Skill*	*Tools*
Basic Task: Control the Controls			
	Respond quickly	Diagnosis	SPC, troubleshooting
	Understand interdependencies	Systems thinking nonlinear relationships	Simulations
	Deal with a nontransparent system	Think in terms of functions not objects	Data arrays, statistics
Basic Task: Contribute to the Design of New Products			
	Design modules	Using specs and deadlines	Scheduling, negotiating, optimizing
	Manage budgets	Cost estimation	
Basic Task: Help Diffuse New Knowledge			
	Research	Use references, interviewing, methods of observation	
	Communicate results	Presentation methods	

Social

	Task	Skill	Tools
Basic Task: Take Roles in a Project Culture			
	Take intergroup roles	Negotiate authority	Role clarification, responsibility charting
	Managing temporary teams	Staging deliberations across time	Meeting management, workshop design
Basic Tasks: Represent Plantwide Concerns			
	Take plantwide roles	Negotiate authority, use power appropriately	
	Manage differences in values	detect and understand the roots of differences	Value clarification

Let us examine this table in some detail. The first part examines the new production, project design and research skills that operators need. The first skill, shaped by the new surface-mount technology, highlights how operators working within an increasingly hands-off technical system must use more cognitive skills and tools for controlling the process. Thus they need to understand diagnosis, systems dynamics, and statistics. The second skill, shaped by their increasingly important project responsibilities, shows how they need to master project design and project management techniques such as scheduling and estimation to be effective project team members. The third suggests that to take plantwide roles and help the plant learn about, as well as communicate, new technical information, they need to develop the skills of investigation research and communication.

These new technical tasks and their associated skills are in turn matched by social skills. It is common, of course, to point out that workers in automated settings need "team skills" so that as they become more interdependent technically they can collaborate more effectively. But as this table suggests, as Circuit, Inc. takes up the more complex tasks of designing products and brokering knowledge, operators must develop particular social skills that rest on the bedrock of team skills but require additional competencies as well.

For example, project teams are temporary systems. Team members cannot rely on past practices and a familiar set of relationships to define their own roles and authority. Instead, they must learn to negotiate their roles, to clarify the authority associated with their roles, and to help the project team configure its role system so that it can work effectively. It is no longer sufficient, for example, for team operators to simply learn good communication skills. Rather, they must learn how to visualize, map, and design a role and relationship system that fits the project task.

Similarly, when operators take up plantwide roles, particularly helping to bring new knowledge about electronics into the plant or export new knowledge to the rest of the company, they will have to learn how to manage differences due to contrasting basic values and assumptions. Thus, for example, in deciding which knowledge base deserves their attention, certain managers and engineers may believe that certain new technology is too obscure while others assume that innovation often emerges from the least exploited areas of a technology. Exploration of this difference may reveal further basic differences in the assumptions people make about technology, about the goals of the competition, and about how progress is made in a particular area of engineering. Learning to clarify these differences becomes an important social skill.

Finally, the last row in the two different charts lists potential tools that operators can use to master these different social and technical skills. For example, to develop the skill of thinking about functions and relationships rather than objects, operators can use the tool of arraying data to discern patterns among operations. Similarly, to master the skill of negotiating authority relationships on a project team, operators can use a tool called "responsibility charting" which provides a language and a system for mapping and designing a temporary system of role relationships. The list is not complete, but it suggests how Circuit, Inc. or a similar factory can create a curriculum based on mastering a set of tools by linking these tools to core skills and tasks.

A Training Typology

In implementing a training system, the Circuit, Inc. community faces the problem of developing a training process that is linked to the changing texture of its social and technical systems. As we have seen, some people feel that the sociotechnical system and the training process are inadequately coupled. One person noted, "I think that the skill-based pay system and training are loosely linked." Another person concurred, saying, "We weren't always precise in what we were looking to get from training. Training was not linked to business goals, and we didn't always place an expectation on people to use what they learned."

The plant as we have already argued was designed with the hope that skill-based pay would tightly couple skills to tasks, while enabling individuals to rise to their highest level of competence. It is clear now, however, that skill-based pay as a system for linking skills to tasks is limited and potentially an obstacle when new technical and social skills undermine the extant set of skill blocks. Describing the problem of linking the training system to technical change, one person noted, "In implementing surface-mount, we didn't have the luxury of waiting for the certification process to give us the skilled people we needed. We hired some people who had some skills and they are doing the work."

Moreover, when the skill blocks help shape the psychological contracts among the operators, the team, and the plant, their instability can undermine social cohesion in the plant. One person felt that operators resented being recertified on surface-mount without earning additional increments of pay.

The following table can help clarify this conundrum by providing a typology of different delivery systems for delivering training.

Form of Training

	OJT	**Classroom**
Current	Skill-based pay (1)	General skills such as computer literacy (2)
Emergent	Vendor-sponsored training (3)	Based on core image and planning anchors (4)

Thus as the table suggests, a training system can focus either on current or emergent skills and can use either OJT or classroom methods for delivering training. For example, vendors will provide training on new equipment, while the plant can provide general classroom training on computer skills. Finally, in a changing technical setting, a plant must provide training that *anticipates* key core skills based on what we have called a "core image" of the model emerging task and role. Such a core image provides *planning anchors* or a guiding framework for curriculum development. As this argument thus far suggests, this core image can be developed by linking emerging basic tasks to the basic mission of the organization and the key relationships it must consequently manage.

The skill-based pay system -- the core of the old sociotechnical design -- is best for only *one of the four* possibilities, that is, when the tasks are stable (and thus are known currently), and when they can be taught through hands-on experience. This same system is less useful when skills are emergent, and/or classroom training becomes increasingly important.

Finally, this table suggests that Circuit, Inc. faces the challenge *of moving from the first quadrant to the fourth* -- from a training system focused primarily on current tasks delivered through a OJT system to one based on emergent tasks that are in turn based increasingly on classroom training. One person noted, "In the skill survey, one thing that came up was that we need to do a lot more in preparing for the new technology. This is not like a dog food factory. We are making quantum leaps." But to prepare for technologies that are not yet fully implemented, the plant community must anticipate the core features of the new tasks and their invariants that match the new technology in its many possible manifestations. To give an analogy, when countries first industrialize, basic literacy is an important fundamental skill in a wide range of new jobs. In other words, it is an *invariant* skill. To be sure, this does not mean that Circuit, Inc. would dispense with the other training modalities. Rather, the salience and specific weight of the fourth modality would grow in significance.

In Sum

Circuit, Inc. faces significant challenges in linking training to its changing sociotechnical system. Challenged by marketplace and technological changes, the company has to manage a more complicated set of relationships. In addition, the new surface-mount technology creates a new set of task demands, and the social system must be based increasingly on intergroup and large group designs, as well as on the individual teams.

When examined, these changes help us develop an image of the new operator who must develop new process control and social skills -- the former based on managing an automated process and the latter in working in a project system. Supporting this development, the plant must invest a significant amount of money and time in training activities. But to do so, it will have to reduce its reliance on its key "pay for learning" and team systems. While at the core of its sociotechnical design, these systems are most useful when applied to a stable technical setting. As social and technical skills change, more formal systems of training are required, which move training into the classroom while reducing operators' dependence on the team process. It has yet to be seen if Circuit, Inc. can make this transition without at the same time undermining the strengths it derives from its basic team system.

III. Cultural Change: Working With The Large Group

Many companies believe that they need to change their "culture" to guarantee long term effectiveness, if not survival. The term culture is of course a problematic one, provoking a complex list of ideas linked to such facets of reality as norms, taboos, beliefs, values, and working relationships. These words describe the typically tacit dimensions of experiences at work -- the experiences people have without necessarily being aware that they are having them.

It is unclear therefore if cultures can in fact be changed though conscious effort, study and training. A cultural system is embedded in practices and is linked to a network of relationships that have been reproduced over decades. It may be that only when facing an organizational crisis or a corporate raider will people confront the tacit assumptions and relationships that shape their behavior.

In spite of this possibility, an increasing number of companies are asking consultants and training companies to help them change their cultures. Companies see training as a vehicle of cultural change. In designing and delivering a seminar for Electro, Inc.'s first line supervisors and their managers, we experienced some of the challenges and dilemmas of designing a training program to help the management of a large system (over 5,000 employees) understand and change the basic texture and culture of authority in the plant.

The following chapter is divided into four sections. The first describes the background and backdrop to the training program at Electro, Inc.; the second describes the principles that the instructional staff used to design the program; the third conveys a feeling for the texture of the training process itself; and the fourth, by summarizing the case study, presents a theory of training as the creating of a transitional space.

Context for the Training Program

The Plant and Its Marketplace

The training manager of Electro, Inc., Jim Miller, contacted us, asking if we could develop a training program to help their first line supervisors become more effective in their roles. Electro, Inc., a large producer of integrated circuits and prototype products for a nationwide communications firm, and employing close to 3,000 operators, supervisors and engineers, had gone through several important changes over the last few years. The plant's current facility had been constructed in the early sixties. It had, however, deep roots going back decades in a rural area which provided it with an ongoing stream of craft workers who repaired machines and women operators who assembled circuits. Advances in computing and communications technology led the plant management to construct large clean rooms filled with semi-automated machinery for laying circuits down on circuits boards.

Walking through the factory, one saw large rooms walled in with glass -- "clean rooms" -- which were filled with machinery for etching circuits, and were protected by buffer zones where operators put on and took off their "bunny suits." The supervisors' desks, crammed into a corner of these buffer zones, were filled with papers and charts -- a measure of the large amount of tracking and monitoring work that supervisors had to accomplish over the course of the day. The plant also had open assembly areas where operators doing "bench work" received the etched boards, and stuffed them with components such as capacitors and resistors. Touring the plant and experiencing its size, scope and capital base, a visitor had the experience of walking through a self-contained world.

The plant played a special role in the parent company's strategy. While producing large numbers of circuits (or "codes") that had been used in the marketplace for many years, the plant also functioned as a "ramp-up" facility for developing and testing new codes. Large numbers of engineers in the plant oversaw the development and testing of new codes. Supervisors thus played a critical role in balancing the plant's work of producing old and new circuits, while engineering-shop floor relationships were critical to the overall success of the plant.

The Deming Seminar

The plant faced growing competition for its circuits in the marketplace. Hoping to improve its ability to meet production schedules without compromising quality and cost, plant management had introduced a quality improvement program based on the consultant Edward Deming's principles of quality control. The program consisted of a videotape of Deming explaining his principles (which emphasized focused attention on the flow of the work itself and greater freedom for operators to suggest and make improvements) and large group discussions on problems in the plant. Every operator in the plant took the course.

Taking Deming's theories very seriously, the plant's senior managers made three important changes to the plant's functioning. First, they eliminated the system of pay that was based on rated jobs. Second, the industrial methods division which developed pay rates based on time-and-motion studies was also eliminated. Third, operators with good attendance records did not have to punch the clock. Thus, as a result of the Deming program the level of policing and control fell.

But the Deming program also created unexpected dilemmas. When given the opportunity to talk about problems in the plant, many operators in the Deming seminars dumped on the supervisors, complaining about their performance and effectiveness. Operators said, "Supervisors won't listen, they are unresponsive to suggestions for improvement, they show favoritism and have pets, and they communicate infrequently with the operators."

Of course, the supervisors felt unfairly blamed and misunderstood. Working at the boundary between the salaried and the hourly work force, they were the shock absorbers for both; they protected the operators as well as they could from strategic uncertainties at the top and buffered the management from the ongoing complexities of supervising a unionized work force with strong craft traditions and many women operators. Feeling scapegoated by both sides and alienated from the plant social system, they dropped out of a shop council management forum that had been designed to discuss plantwide problems. Miller, the training director, felt that the supervisors needed a program of their own to repair the damage of the Deming program while also helping the supervisors adapt to a new way of working and supervising. Could we help him?

Learning About the Supervisory Role

But as the Wharton team discovered, the Deming program, while a stimulus for the supervisors' disenchantment, was not the culprit. Conducting research at the plant prior to designing the seminar program, we found that the Deming program *had reinforced longer term changes in the nature of supervision on the factory floor.*

To understand the supervisory role, we took two tours of the plant, conducted interviews with twelve supervisors, shadowed two supervisors over the course of a shift, and did four group interviews with operators, maintenance workers, engineers and upper managers. While the Deming seminar and its paradoxical impacts were still vivid to many of the supervisors, our interviews suggested that the supervisor role was undergoing stress and change as a result of processes far more powerful than the Deming seminar alone. Indeed, the social status imbalance that the seminar induced was simply one part of a larger set of economic and cultural changes that were reshaping the supervisory role. The Deming seminar had *focused* discontent and anxiety but was not their *cause.* Examining the resulting data, we developed five hypotheses about change in the factory which ultimately shaped our thinking about the seminar design.

First the plant itself was experiencing a significant change in economic context. Deregulation and competition had increased the importance of meeting customer needs and producing quality products rather than just meeting production quotas. Facing cost pressures, plant management had to economize on all plant resources. This meant that they had to keep inventories to a minimum, while meeting schedules by reducing time intervals rather than by maintaining large buffer stocks. Interdependence among units and departments was growing, so that supervisors had less and less control over their own units.

Second this new context created pressures for developing a new culture of managing and working in the plant. Growing interdependence meant that the relationships among managers had to become more open. As one supervisor noted, "We are changing the philosophy to get rid of the old ways. The empires have to be torn down. They are too expensive today."

But while necessary, cultural change was difficult because people were feeling much anxiety and at significant risk as the new competition reduced the factory's market share. Jobs were on the line and, as our interviews suggested, morale in the plant was quite low. How could people take the risks of developing new relationships when they worried about the basics?

Third, the culture of authority in the plant was changing. In the old days, several supervisors noted, people did what they were told and felt loyal to the company. But since jobs and careers were no longer secure, people were unwilling to give up their freedom to think in exchange for an unpredictable career or an unstable job. The supervisors faced a contradictory situation. On the one side, operators were less willing to follow instructions, and this could create problems. On the other side, operators might be more willing to take initiative and this could help supervisors do their jobs. The supervisors could not be sure which tendency would dominate.

Fourth, changes in the structure of the plant had already reduced the power of supervisors, as well as of all shop floor management. In particular, the growth of staff groups, such as production control and customer service, and engineering's growing importance in developing new electronics products meant that the supervisors were much less able to control how they managed the production process in their own sections.

Fifth and finally, by shadowing two supervisors we saw that they spent relatively little time directly supervising operators, and much more time working with peers and superiors. They were pulled upward and outward.

The following table, which we distributed to participants in all the seminars, along with a brief review of our research results, summarizes these shifts.

SHIFTS IN THE SUPERVISORY ROLE

From	Toward
The Supervisor	The Coordinator, the Manager
Primarily Downward	Primarily Outward
Understands the Technical Details	Understands Capacities and Constraints
Hands On	Hands Off
Commands and Directs	Supports, Enlists
Motivates Through Instruction	Motives Through a Sense of Direction
Knows the Section	Knows the Plant
Knows a Product	Knows a Business

In effect, the Deming program was part and parcel of broader structural changes that raised critical questions about the supervisor's authority and power. Clearly, a training program responsive to this setting could not simply focus on supervisory skills but had to account for the unstable and dynamic context that was re-shaping the supervisory role. The training program would educate as well as train, and would have to focus on the total role system in the plant as well as on the dilemmas facing supervisors.

Designing the Training Program

Jim Miller, the training coordinator, seemed to understand the special nature of his need and situation. When approaching us, he noted that they had spoken with other consulting firms and organizations but were dissatisfied with the "off-the-shelf" materials the firms had submitted. Miller wanted to know if we could develop a program specifically for Electro, Inc. Using a phrase he repeated many times in the future, he wanted to know if we could "learn them," that is, really understand their particular situation in order to help build a context or framework for a supervisory training program.

Our proposal was responsive to both his interests and those of the management committee that advised him. We suggested that we first do a pilot seminar before they committed to training all 120 of their first level supervisors. We would collect data on the supervisor's role through direct observation and research, and our training design would facilitate interaction not only among the supervisors but between them and people in other roles in the plant. Indeed, since the presenting request linked the supervisors' dissatisfaction to their place in the plant culture (Were they really the "bad guys?" Should they have shouldered all the blame in the Deming program?), we conceptualized the training program as focused less on the *skills* of supervision and more on the *roles* of supervisors, on their *relationships* to other roles in the plant. This meant that much of our work would focus on how the *structure* of roles and relationships shaped a supervisor's behavior and competence. We needed to link the training program to the beginnings of a broader organizational development process.

Our proposal thus noted that we would first conduct research on the supervisor's role by interviewing supervisors and other role holders (e.g., operators, maintenance workers, engineers, and upper managers), and by observing two supervisors over the course of a complete shift. In addition, we suggested that the "supervisor's seminar," as we called it, would be based partly on a review of our research results, a study of a series of "critical incidents" that supervisors would themselves write, a look at the broader economic context which was shaping the plant's current and future prospects, and a series of planned encounters between supervisors and their bosses. In others words, responding to their interests and needs, the training program would be interactive, focusing on roles as well as skills. It would be based on their experiences, and would link different members of the plant together through a series of seminar "episodes."

What We Did

We conducted four seminars over the course of eight months, each lasting two and a half days. We worked with a total of about 120 supervisors and 20 engineering and production-shop managers. The plant manager and his assistant attended every seminar.

In designing such a seminar, we faced a central challenge. When people come to a training program they expect to be instructed, to be told how to do a task or accomplish a goal. Yet plant community members faced a problem that went beyond skills and tasks. They needed to develop a climate or culture in which people were willing to innovate to solve problems. But to experiment, people could not be afraid that failure or ignorance would isolate them.

The Deming seminar experience, our initial interviews and our later experiences suggested that the plant faced a two-fold cultural challenge. First, many of the supervisors entered the plant when the "division chief" was, as one supervisor noted, "like god" whom you only saw on your anniversary date. You did what you were told, kept your nose clean and didn't make waves for fear of being judged or shamed. Second, as we have already argued, the changes at the plant, the new organization of work, and the growing competition made people feel insecure. If they stuck their necks out now, would they have a job? The risks of trying something new might be increasing. Could upper management be trusted? Thus, just as the marketplace favored innovation, the new insecurities might reinforce a culture of "lying low." The plant needed a training program or seminar that stimulated people's capacity to learn and think -- and indeed be confused -- *in public*. If we took up the roles of experts and "told" them how to act and learn, we would simply be reinforcing their old culture. The content of our message ("be innovative, take risks") would contradict our relationship to them ("listen to what we have to say").

Thus we saw our central challenge as designing a seminar that stimulated their participation and learning and enabled us to take facilitative and learner roles as well as expert roles. *Their relationships to us, and ours to them, in the seminar had to model the relationships they needed with one another to build a new culture of learning and authority.*

The Dilemma of Authority

Indeed, the issue of authority was central to the problem of cultural change. On the surface, upper managers said they wanted "participative management," and supervisors could agree that they wanted to participate, but there was a great deal of fear, anxiety and mistrust that made it difficult for the two groups to recalibrate their relationships.

Our research and experience suggested that there were many missteps in this dance. For example, the plant manager frequently noted in the seminars that he was eager to step aside, to let the operators and the supervisors "take over" the running of the plant." But we felt that the supervisors often experienced this as a form of abdication, as an expression of the plant manager's lack of interest and care rather than as an invitation to share power. Similarly, we often felt that the supervisors overestimated the plant manager's actual power and control in the company and blamed him too much for plant dysfunctions. They complained endlessly about the pay and rating system for first line supervisors, knowing full well that the plant manager could not change it, that pay policies were set by the corporate personnel department. At times we felt that the supervisors needed to believe the plant manager had more power than he did, simply because it was more frightening to think that he had little power in the corporate system! Unless the seminar provided a context for people to view each other realistically, and take and experience authority in new ways, it could not contribute to a program of cultural change.

The Evolution of the Design

As our working relationship to the supervisors, Jim Miller and the plant manager deepened, and as we learned more about the plant and the issues it faced, the seminar design evolved. The following insert summarizes the discussion and work for the third seminar while the chart following the summary shows the form and structure of all four seminars. The chart and insert together convey in some detail the structure of the training seminars and the texture of the work. Explanations and examples of the different entries (e.g. "interview design," and "critical incident") are included at the end of this section.

Third Supervisors Seminar

Tuesday AM. The seminar began with a taking of the history of the plant. The oldest member had joined in 1952, the youngest in 1984. The theme of the changing nature of authority in the plant emerged as central to the discussion. Old-timers noted that there were more levels of authority in the past, with the group leader coming one level below the section chief. The supervisor in those days had more authority; people never looked behind him to some other higher authority. There was a white shirt code, a "telling" culture, and no asking of input. There was also a sense of family and a feeling that one could have a lifetime career at the plant. Changes in the culture are very recent, perhaps with the eighties, stimulated in part by the introduction of participative management.

Some supervisors noted that the plant always had an engineering dominated culture, but that now the engineers were coming onto the floor more frequently because of the changing technology.

Group Work and Interviews

Shifts in the supervisor's role. The supervisors reviewed the Wharton chart on shifts in the supervisor's role. They agreed that there are major shifts in the role, such as relying on rather than commanding operators and knowing more about the capacity of a line than its technical details. In contrast to the Wharton charts, they feel that the supervisors need to know much more about the plant, that in fact the plant may be becoming more divided by the different lines.

On performance measures. The supervisors reviewed the ranking given to different attributes and noted that the upper managers and the supervisors generally agree on how supervisors should be ranked. Therefore it seems that the way in which the uppers rank the supervisors is inconsistent with their opinions. Why? It was felt that perhaps this discrepancy arises *because appraisals are shaped by political processes as well as by compromises between different senior managers.* Some supervisors also noted that, in describing the current rating system, leadership and customer orientation are ranked low. Why should this be when uppers and supervisors agree that leadership and customer orientation are in fact important?

On norms. One group reviewed a set of norms that Wharton has proposed as descriptive of the plant's culture. The norms were: 1) It's not okay to say "I don't know;" 2) Don't challenge your boss in public; 3) Meetings are used to diffuse risk; 4) The culture supports judging others rather than learning and inquiring along with them; and 5) People jump to solutions, rather than work out a solution with others.

The group disagreed that the first two are norms. They thought the third might apply to meetings above their level. They thought that indeed people might judge others too quickly because if someone else looks bad, you look good. And finally, they felt that often people in fact *avoid* making decisions rather than jump too quickly to them.

On team development. The group generally agreed that a team culture had not yet been developed at the plant. In terms of the list of next steps produced by the prior seminar, they particularly supported: redesigning the appraisal system; building more trust and honesty in the chain of command; improving the links between supervisors, engineers and others in the "value adding" chain by emphasizing the customer.

The Seminar

The supervisors then discussed the seminar itself, wondering if it was just another fad, and asking why they had to leave the plant, go to a hotel to talk, and use intermediaries to talk to their bosses. They noted that uppers don't always listen to outsiders. Others asked, "How will we know if we are heard?" Some supervisors noted, however, that the uppers may hear what supervisors are saying, but that some things may be beyond their control, e.g., the rating system is corporate-controlled.

Tuesday PM. The Wharton group introduced the theme of working with engineering. Engineers shape the supervisors' work, yet they had not been members of this seminar. After a general discussion of the relationships between engineers and the supervisors, there was an extensive review of the engineering change notice problem. Many supervisors felt that the engineers simply don't document the changes they make, which makes it very difficult for the supervisors to know what is or should be taking place in the process. This becomes a greater problem when the engineers themselves are shifted from one section to another. One supervisor argued however that as the work of the engineer becomes more developmental and experimental, it becomes harder to document changes. Another noted, however, that if there was agreement all the way up the line that engineers must follow the discipline of documenting changes, then it can be done.

The seminar members then discussed if a supervisor can take a stand on following procedure and refuse to accept a change to the process unless it has been documented. A supervisor noted that you have an imbalance with one supervisor looking after 120 operations and 20 engineers who are each worried about their own turf in this same set of operations. The discussion ended with a concept of an audit or check list to help a supervisor assess if he or she is effective in working with engineers and integrating engineering knowledge into the line. The check list consisted of four items:

1) Is a supervisor quickly informed of engineering changes to the process?

2) Is a supervisor using his or her technical assistant effectively in linking the engineers to the shop?

3) Does the supervisor take the risk of saying "no" to the engineer when documenting a change?

4) Does the supervisor help the engineers and operators work together?

Critical Incident

The group then continued the discussion of engineering-shop relations by discussing the following critical incident.

> "The testing area I supervised was running flat out seven days a week. Since testing was a bottleneck, we were keeping the test sets manned every hour, resulting in a lot of overtime for the operators. But operators in the wafer fab section, which I also supervised, were working normal hours. To give them overtime opportunities while spelling some of the testing operators, I gave the latter time off and backfilled the testing area with wafer fab people on the weekends. I trained the wafer fab people to operate the test sets.

> One of the codes in the testing area began to experience yield problems. An engineer, believing that my system for allocating people had caused the yield problem (although he had no data to prove this), demanded that only testing people work in the area on the weekends. I argued, but lacking data I had to back down, resulting in strained relationships between the engineering supervisor and the operators.
>
> This encounter highlighted several issues. Who calls the shots in the shop? Why was the engineer taking such a shot-gun approach? Why didn't the engineer certify the wafer fab people? And why did I have to bow to political pressure and operate in a less efficient manner?

The supervisors explored this incident through discussion and role plays. They then examined why the two couldn't agree on an experimental period for assessing the cause of the problem and how the supervisor could take the authority of his or her role without getting into a fight with the engineer.

Wednesday AM

Labor relations. On the second morning, the supervisors discussed a case involving an operator with a very bad absence record by examining excerpts from her file assembled by labor relations. Two managers from labor relations participated in the discussion. The case of frequent absence led the supervisor to constantly track down the woman, to check her stories by calling her home, the hospital, etc., and to blow up and yell in front of others, "You are making a fool out of me." The Wharton instructor suggested that the supervisor had become a victim himself in all this, as if he, rather than the operator, were the problem.

The supervisors discussed this case at length. Two themes emerged. First, the supervisor may too often be called upon to play too many roles in relationship to a poorly performing employee (e.g., supervisor as counsellor, boss, parent and spy). How can the supervisors take a coherent role as the employee's manager and stay in the adult-to-adult relationship without being sucked into all these other roles? Second, do supervisors underutilize the power of the operator team to contain and limit the disruptive effects of one bad worker?

Wednesday PM

Responsibility charting. The group was introduced to the tool of responsibility charting in which different roles are given different levels of responsibility for a particular decision. The group then divided into six subgroups, based partly on the lines in the plant, and charted a range of decisions. For example, one group chose to examine attendance record management, another chose to examine the decisions to scrap an air-handling unit. During this work, the upper managers came to the seminar and joined the different groups.

The plant's wider environment. The Wharton instructor talked to the full group of supervisors and upper managers on the links between an organization's wider environment and internal organizational processes. He showed how in a high value-adding setting that encourages innovation, people's responsibility may exceed their authority at all levels leading to a great deal of negotiation and cross-talk to accomplish work. He suggested that the plant lives in a very complicated stakeholder environment which is reflected in the growing complexity of its internal structure. The plant and its parent company, he felt, has yet to fully define how it will situate itself between the high value-adding and low cost producer strategies. It is difficult to do both.

Airplane Factory Simulation

Wednesday PM. The supervisors and uppers took part in a simulation to test the effects of different work designs on work group productivity teams. Groups first organized as assembly lines and were given a sheet of paper to fold into an airplane according to specific directions. A quality control inspector at the end of the line accepted or rejected the resulting planes. After a 20-minute run on the assembly line, the groups were placed in small self-managing teams and were told to organize their work any way they liked. When the two simulations were compared, it was clear that the second simulation produced more acceptable airplanes using less paper than the first. In general people were quieter in the second, and the QC inspector found it easier to communicate with the groups in the second when compared to the first.

Thursday AM. The supervisors and uppers gathered to discuss the following critical incident written by an upper manager.

> **Background:** Due to a sequence of events over a several month period, a code was backscheduled and on the Critical Code Report. The supervisor and I were working on a plan to get the code off the critical list.
>
> **Encounter:** During the course of our discussion, I was arguing for accepting more program during the next few weeks. The supervisor did not believe we could accept any more than what was already promised. When the capacity of the various pieces was analyzed, the number of people appeared to be adequate although somewhat tight. I therefore asked the supervisor for specifics of where he thought the problem might be. He could give me no specific answer. I concluded that we could accept more program. He agreed, but I felt that he didn't really believe it could be done.
>
> **Frustration:** I found this experience to be frustrating because I felt there was something the supervisor wasn't telling me. He definitely didn't appear to believe we could make the program. He was only agreeing because I was "browbeating" him into doing so.

The discussion of this incident highlighted the following issues. The upper wants to get the supervisor's real thinking about a production problem but feels that he or she obtains only compliant behavior. The supervisor seems wary of saying what is on his or her mind. But yet both are frustrated and may therefore impute to the other various motives to explain the failed communication. The upper may say, "The supervisor does not want to cooperate with me," and the supervisor may say, "My boss already knows what he/she wants, so why is he/she bothering me?" The role plays suggested that someone must take the risk of communicating about the lack of communication *as it is happening.* But this seems difficult. One role play also suggested that a customer versus a production orientation would have helped communication, since both the supervisor and the upper would then have been concerned with credibility with the customer. The role plays also suggested that people have choices, that not all is determined by culture, structure or roles.

Engineers in a fishbowl. A group of engineers were asked to join a fishbowl discussion to talk, in front of the entire group, about the same critical incident that the supervisors had examined the day before. (See first critical incident above.)

The engineers' discussion highlighted several issues. Should the engineer have been consulted before the operators were put on the test sets? Who is responsible? Also one discussant felt that if the supervisor said no to the engineer, the engineer could have felt justified in taking it up the line, since it was now a confrontation. The Wharton instructor suggested that such ambiguities and conflicts are inevitable in a developmental setting, but why can't the two get together and figure out a way to solve the problem by constructing a test, for example, to assess the cause of the problem? Why the engineer's snap judgment? The incident suggested that in the absence of a learning culture, creative approaches (which will sometimes prove wrong) will not be tried.

The chart on the following page shows the modules that went into the construction of a particular seminar. Below are several explanations of key terms that are used frequently in the chart.

Interview Design: A structured method for facilitating participant-to-participant interviewing.

Taking the History: A structured method for quickly developing the history of a setting by asking people to identify the year in which they joined the plant.

Critical Incident: Using case incidents written by participants to explore the dilemmas they face in taking their roles.

Fishbowl: A method for focusing on the thinking and working of a particular subgroup of participants.

	DAY 1			DAY 2			DAY 3	
	Morning	*Afternoon*	*Evening*	*Morning*	*Afternoon*	*Evening*	*Morning*	*Afternoon*
Seminar I	Interview design "key issues and themes" Lecture on economic context	Examining the changing role of the supervisor What do other roles think?	Planning for when upper managers come	What is purpose of seminar? Critical incidents	Prepare for upper management Advice on training Personal next steps	Upper management review supervisor's work, thoughts	Mixed groups of supervisors and uppers meet List of "next steps" for the plant	Comments by plant manager; pairs talk about individual next steps
Seminar II	"Taking the history" of the plant Interview design	Examining the changing role of the supervisor Norms and taboos in the plant culture The plant meeting system		Critical incidents	Purpose of seminar Lecture on economic context: uppers and supervisors Responsibility charting: roles and relationships on technology: uppers and supervisors	Upper managers meet; review work of supervisors	Critical incidents: uppers and supervisors	Comments by plant manager; pairs talk about individual next steps
Seminar III	"Taking the history of the plant Interview design: supervisor roles, norms, performance measures, purpose of seminar	Engineer-shop relationships Critical incident on engineer-shop interaction		Reviewing a case of a "difficult worker," working with labor relations at seminar	Responsibility charting on product line decisions; uppers arrive Lecture on economic context	Factory design: a simulation	Critical incident: upper-supervisor Critical incident: engineering-shop Plenary: individual next steps	
Seminar IV	"Taking the history of the plant Reviewing past work of seminars	Fear and risk-taking in the plant culture Review of recent initiatives in the plant		Critical incidents Recommendations for future training	Exploring horizontal relationships between departments Risk-taking and fear: upper managers in a fishbowl		Lecture on economic context Upper management fishbowl: plant culture and "next steps"	Different "chain of of commands" meet, dscuss learnings from seminar

Six Developmental Tendencies

As the chart suggests, our work highlighted six processes which shaped our design and process work: learning while working; bringing the plant inside; going from the supervisor to the social field; focusing within rather than outside the seminar; and going from design to conversation. Let us briefly examine each one in turn.

Learning While Working. First, since we were developing the training program from scratch and were committed to developing a climate for learning, our design changed and developed over the four seminars. Simple changes (such as when the lecture "Changes in Economic Context" was given) were matched by substantive changes, such as how and through what task should the upper managers and supervisors interact. Thus in the first seminar they worked in small discussion groups at the end of the seminar, in the second and third seminars they worked on critical incidents cases together, and in the last seminar the uppers worked in a "fishbowl" in front of the supervisors, where they talked about the difficulty of discussing themes of risk and fear in the plant.

Second, this meant that if we could navigate the tension between offering seminar participants substantive content and a predefined structure in which they could work, while also claiming our own right to be learners, we could be responsive to their spontaneous learnings. We would not follow a predefined script, a fixed "lesson plan." Predictably, this process could stimulate anxiety when seminar participants were uncertain of where they and we were going.

An episode in the first seminar highlighted this process. Discussing the seminar's purposes on the second day, one supervisor argued that unless the upper managers were aware of the seminar's discussions, it could have no impact. Another noted that upper management needs to really implement teamwork, not just give it lip service. A third supervisor then said that he was tired of always complaining, "What is the purpose of the seminar?"

In response, a Wharton staff member gave the background of the seminar, and suggested that the term "training" is not quite right to describe what was going on. A supervisor then noted that hourly employees often just vent their negative feelings at these seminars, "...and we are doing the same. Is this the way it should go?" Finally the supervisor discussed the limits that upper management imposes on the supervisors and noted that you can't go to upper managers with a problem unless you know the answers. A Wharton staff member, feeling the resonance between the theme of confusion in the seminar and the inhibitions to learning in the plant, responded by noting that the same impatience upper management feels when facing confusion, the supervisors have felt in relationship to the seminar. Both find it difficult to suspend judgement, confront confusion, and work through the difficulties of learning from their experiences.

In short, working through the medium of an open-ended conversation, rather than a scripted lecture, the instructors could help the supervisors see how their struggles with the seminar, its purposes and its content, reproduced the broader cultural issues they faced. They were not simply victimized by the plant's culture but participated in it as well. Thus, the seminar experience, the *process* of learning within it, as well as the *content* that filled it, became an occasion for learning on the part of the supervisors and the instructors.

Bringing the Plant Inside. Third, as work with the plant evolved, and supervisors could tolerate some of the uncertainty embedded in the seminar space, we were able to increasingly focus on actual working relationships *within* the training space. The seminars became less about interactions and conversations that might take place *after* the seminar and became more the occasion to have these conversations *in* the seminar. As the following table shows, each seminar contained a broader array of roles, so that the seminar increasingly was designed to facilitate a cross conversation between them.

ROLE RELATIONSHIPS THAT WERE PRESENT AND WORKED WITH IN THE TRAINING SESSIONS

Seminars			
1	2	3	4
Supervisors/Uppers	Supervisors/Uppers	Supervisors/Uppers	Supervisors/Uppers
		Supervisors/ Engineers	Supervisors/ Entire Chains of Command
		Supervisors/ Labor-Relations	Supervisors/ "Value-Adding Chain"

As the table shows, engineering managers attended the third seminar and were actively engaged in the seminar work. In the fourth, we had entire "chains of command" from the top down meet as groups to review their own working relationships.

From the Supervisor to the Social Field. Fourth, as the seminar evolved, we asked people other than supervisors to explore how they took their roles, how they understood the core dilemmas of the plant, and how they might change their behaviors. We shifted figure and ground so that the presenting problem was no longer the supervisor but the social field *surrounding* the supervisor. Thus, for example, in the first seminar the supervisors did most of the exploratory work and the upper managers primarily "reacted" to what they heard. But by the fourth seminar, we asked one group of upper managers to work in front of the supervisors on the themes of risk taking and fear, and one group of managers (including the plant managers and his assistant) to assess the meaning of the four seminars as a whole for the future of the plant. Similarly, in the third seminar we asked a group of engineering managers to discuss a critical incident written by a supervisor in front of all the supervisors.

Focusing Within Rather than Beyond the Seminar. Fifth, as we focused increasingly on actual working relationships in the seminar room, we found it less important and helpful to create lists about "next steps" that people in the seminar might undertake *after* the seminar. Instead, the prospects and ideas for change could develop naturally and changes could take place in the "here and now" as the different role groups worked with each other in the training space itself.

To be sure, trainers typically ask people to create such lists with the rationale that such lists create a context for applying the learnings of the seminar to the actual world of work. But frequently, such lists contain ideas and hopes that far exceed the authority of those in the seminar to implement them. They become, as many seminar participants noted, "wish lists," and when posted up on a wall are often derisively regarded as training "wallpaper."

An interaction we had with seminar participants in the second seminar is revealing. Approaching the time when the upper managers would join the seminar, our own training team felt viscerally how unrealistic it was to ask participants to create a list of "next steps." Supervisors couldn't make changes alone, nor could the realism of such a proposal for changes be assessed outside of an ongoing conversation between the supervisors and plant management. This author recalls feeling how much "next steps" lists functioned as ritual objects to contain the trainers' and the participants' doubts and unease over the usefulness of the training session. Like the problem of mistaking the menu for the meal, such lists help people confuse the *wish* for change with the *work of changing*.

Though the schedule called for it, the Wharton staff decided to eliminate this activity from the seminar and to tell seminar participants why. Predictably, some of the supervisors were upset. "Why are we here then, and what can we do?" We acknowledged that by eliminating such an activity we were raising questions about the seminar's purposes, but in raising these questions we could also be more realistic about the seminar and do work that, even if limited, was genuinely productive. Talking in this way with the group, we and the supervisors decided to do a modified version of next steps focusing only on those activities that people believed were entirely within their own authority to carry out.

From Design to Conversation. Sixth and finally, as our understanding of the plant, its history and its functioning evolved, we focused less on techniques for engaging seminar participants in thinking and talking and were able to rely on the dynamics of the conversation itself. In the first pilot seminar we spent a great deal of time each evening revising parts of the original design. By the third and fourth seminars we found that conversation alone, without training techniques, were sufficient to create a spirit of serious work and a commitment to the seminar.

Evidence both of our own growing ability to work with the supervisors and other roles and the plant community's ability and willingness to work with us was the speed and sophistication with which seminar participants examined and critiqued the seminar's purpose in each successive session. As they felt both entitled and authorized to work with us on assessing the seminar's purpose, the work itself became more collaborative, more conversational and less dependent on our cleverness as training designers. For example, purpose and method were difficult to address in the first seminar. Only when the upper managers were about to appear did seminar participants examine why we were "simply not giving them answers" and why we were adjusting the seminar design itself. Entering the training seminar with the natural expectation that they would be trained, it was sensible for them to assume that the design would be fixed and that they needed to master particular ideas and concepts to become more effective supervisors. By the third seminar they could discuss the seminar's purposes the very first morning, and in the fourth the seminar's purpose was no longer of central concern. The plant community had taken us in, and had accepted our offer to work with them.

The following table highlights these shifts in the seminar's process as it unfolded from the first to the fourth.

THE SEMINAR'S DEVELOPMENT

From	To
working with role relationships hypothetically, in the abstract	working with real role relationships in the seminar room
working with supervisors and their experience of other roles	working with other roles and their experience of supervisors as well as of other groups in the plant
working with role	working with real
focusing beyond the seminar to improvement that might be made in the plant	facilitating change by working on roles relationships in the seminar itself
relying on design and technique to link participants to the seminar	relying on conversation and content to link the participants to the seminar

The Feel of The Work: Change or Training

Working in a training setting, professional trainers take up expert roles intent on delivering knowledge and expertise in an efficient way. Participants are students who accept the authority of the expert and are helped to absorb the knowledge through repetition and practice.

But when we enter the arena of training as a vehicle of cultural change, the trainer's role becomes more complex and ambiguous. Three challenges are evident. First, people can hardly be trained to change their culture by reading a book or listening to a lecture since by definition they are unaware of their own cultural biases.

Moreover, no book or lecture can reveal their particular biases to them since by definition these biases are unique, and are reproduced through actions.

Second, while people may draw some insights from the experiences of other settings, companies or communities, the real learning happens only when these insights are turned inward on the community, organization or factory itself, when they provide a context for self-study. Third, as we saw, an *individual*'s skills and deficits do not represent or map the dynamics of the culture. The culture is contained in *relationships*.

Three Modes of Working

We found that when the seminar worked, when it helped participants study the plant culture, it worked as *dynamic conversation* in which the staff and the seminar participants tried to make sense of the complexities of the plant's social system by taking up three different kinds of roles. We could advance or facilitate a conversation, we could challenge and confront thinking, and we could uncover suppressed or unacknowledged experience. Let us examine each one in turn.

Advancing the Conversation. Return to the third seminar and consider the conversation we had on the seminar's purpose the first morning. Our notes highlight the following flow of talk among our three staff members and approximately thirty supervisors sitting around a seminar table.

> **Supervisors:** "Why does upper management always have to go outside for training? Why were you selected?
>
> **Wharton Staff** gives brief history of their involvement -- highlights the fact that the training department wanted a training group who could "learn the plant" and not give them off-the-shelf solutions.
>
> **Supervisors:** "But even when they go outside, the upper managers don't always listen to what the experts say. They had this production guru in. He had some good points, but many upper managers turned away just because they were put off by his language."
>
> **Supervisors:** "How do we know if the upper managers have heard us? Is it that they hear but don't have the ability or the authority to do something about it?"
>
> **Supervisors:** "I wonder what our people would say about us. They might say the same things."

> **Supervisors:** "We have been given goals and guidelines, and that is a first step, but it is hard to know how to translate these things into practice."
>
> **Wharton:** "It is difficult to link outside training in hotels back to the plant. It does help to bring other people to the hotel though. Tomorrow we will have labor relations people here and the upper managers. But there are limitations to working this way. It could be a place just to vent frustrations, but it could be a first step."
>
> **Supervisors:** "Change needs support from the top."
>
> **Supervisors:** "How come we didn't use our corporate training group for this seminar?"
>
> **Supervisors:** "I went to one of their seminars. You get all psyched up, ready to take on the world, like you see flowers everywhere. But then it fades."

The conversation is direct and at times tough. The seminar participants want to explore the purpose and meaning of the seminar. They dump on their bosses but then one of them notes that their own operators might talk about them in the same way. They are concerned with the problem of implementation, and one of them is quite sophisticated about the allure of training programs that get you psyched up but fail to connect your thinking in the training program to the policies of your work environment. Our role in this situation is to *advance the conversation*, so that it remains direct, stimulates participants' own thinking and builds a conversation among them as well as between them and us.

Challenging Thinking. Now consider the following conversation between a Wharton staff member and the group discussing a labor relations case. This discussion is stimulated by a memo in the labor relations file of a problematic woman operator. Her supervisor reports in the memo that she is frequently absent and late, and uses the phone on work hours. The supervisor seeing her on the phone tells her to hang up, saying, "I told you: 'Break and lunch, break and lunch -- you may use the phone on break and lunch.'" But later, seeing her on the phone again during work hours, he loses his temper and yells, "You don't pay any attention to what's said, make a fool out of me, and don't care about your job."

The supervisors have all read parts of the case file the night before, and the Wharton staff member begins the conversation: "Why does the supervisor say, 'You make a fool out of me.'"

> **Supervisor:** "I can't believe that it was in the memo. I would never write that I ranted and raved. We do not put ourselves in that position."
>
> **Wharton:** "If it is unusual, what is going on for the supervisor?"
>
> **Supervisor:** "He is pointing out that he lost it; he is frustrated and lost his cool."
>
> **Supervisors:** "Probably a number of other shop people heard him and saw it and he had to include it to protect his ass."
>
> **Wharton:** "He seems beleaguered, a victim of the process."
>
> **Supervisor:** "He wanted to put on paper what he was thinking. Since the memo readers hadn't seen what happened, he was trying to get them to understand this."
>
> **Wharton:** "We have three theories of his behavior -- bizarre, cover his ass, put it down under stress -- to communicate what was going on."
>
> **Wharton:** "It is striking he feels as if his ass is on the line. He feels as potentially exposed as the operator he is trying to discipline."
>
> **Supervisor:** "He was feeling attacked personally."
>
> **Supervisor:** "The worst situation is that the people see somebody getting away with something like a medical restriction or lateness. You are doing all the paperwork on them, but it is invisible. Your people put pressure on you. They think you are letting someone get away with all this. It makes you feel inadequate about the fact that you are not handling it."

As the conversation unfolds, the Wharton staff member develops the paradoxical point that the supervisor has become the victim and appears as inadequate as the recalcitrant operator. This point in turn leads the Wharton staff member to explore with the supervisor the kind of culture and process that leads supervisors to feel like victims. The supervisor it appears takes up both the scolding parent role as well as the victim role. But the supervisors and operators are unable to develop an adult-to-adult conversation. This leads the Wharton staff member to reflect on the many ways in which the plant, as a community institution which has provided people with jobs for decades, actually protects people from work they don't like to do, and sustains a paternalistic culture .

> **Wharton:** "Let me push you. There are lots of people who get lots of exceptions here, like medical exceptions. This is really a nice place; people's special needs get attended to."
>
> **Supervisor:** "It's a jungle out there." (laughter)

> **Supervisor:** "Deals are made in roundabout ways that the supervisors have to live with. If the supervisor were present, then it would be more equal."
>
> **Wharton:** "The supervisor takes up the scolding parent role. It seems it is impossible to have an adult-to-adult interaction."
>
> **Supervisor:** "According to our psychology courses, there are sometimes only certain ways to deal with them. You take the parent role because they take the child role."
>
> **Supervisor:** Some of these cases take a year and a half. One case became my obsession -- it became the first and last thought of the day. I grew to hate the person. I was the child. I could not concentrate on getting the job done. In my mind I felt that the other person was plotting to get me."

In this interaction the Wharton staff member, by challenging the supervisors, works with them to explore the paradoxes of the plant culture. On the one side the operators are supposed to apply rules and enforce discipline; on the other side, the plant is a "nice place" where exceptions are made to help people adjust to their work. This situation makes the supervisors feel helpless and as ineffective as the operators they are supposed to discipline. They become the victims. In this context, the trainer's purpose is not simply to advance the conversation but to deepen people's thinking. The trainer must help participants understand some the contradictions and paradoxes of a work setting that often makes it difficult to understand one's own experience.

Uncovering. Finally, consider the following study and decision of a critical incident. The incident, written by a supervisor (who remained anonymous), was discussed by the full group of supervisors and upper managers.

> A forecast of the number of employees with decreasing workload was decided on for the upcoming year. This decision was made jointly by all departments and supervisors, with input from all.
>
> Some months after the surplus (i.e., layoff), unforeseen by everyone, the business picture (as usual after a surplus) turned around. The workload increased. The statement made by the supervisor was one of, "I told them not to surplus anyone." This is where frustration set in.
>
> The supervisor had contributed to the overall and final decisions. I felt he did not want to be looked upon as part of a team who made the decision. When I had a meeting with the supervisor (privately), I mentioned the statement. The answer was, "Well, I get frustrated that we surplussed the people and now the workload is increasing and I felt as though my employees thought that we don't know what we are doing."

> My answer was, "You were part of the team. If you didn't feel comfortable with the decision, you should voice your opinion and state the reasons. Also, explain to your employees how and why the decision was made and if need be, I'll sit with them and explain it to them."
>
> I also mentioned that this is part of being a manager and that one tries to make the best decision at the time, based on the information at hand and one's knowledge of the nature of the business.
>
> The conclusion was that the supervisor admitted it was the wrong statement and he had not used good judgment. The incident and discussion helped the individual to become a better supervisor and accept his responsibility as part of the management team.

People first discussed the incident in small mixed groups (supervisors and upper managers of three or four people) and then turned to the Wharton staff member (Hirschhorn) for a plenary discussion of the incident. The transcript for the discussion is missing but the conversation in its basics was recorded in notes after the session.

The incident itself is a rich one. It highlights how upper managers can feel frustrated by their inability to enroll the supervisors. It shows the link between upper management failure (e.g., they laid off too many people) and the breakdown in the relationship between upper managers and supervisors. It underscores the supervisor's fear of complaints from operators and fear of pressure from bosses. It also suggests that upper managers, engaged in wishful thinking, may see resolution and continued support for their authority where both are lacking.

The Wharton staff circulated among the small mixed groups during their discussions and were pleased by the freedom with which the supervisors were speaking. In particular, many supervisors pointed out that they doubted the supervisor in the incident had indeed accepted "his responsibility as part of the management team" and may have simply been agreeing with the upper manager to avoid further conflicts.

One of us (Hirschhorn), who was leading this session, then convened the whole group in plenary and asked them to review the themes of their own small group discussion. The supervisors found it easy to characterize some of the feelings that the upper manager felt, e.g., "he felt betrayed, disappointed, frustrated." But when the mixed group of supervisors and upper managers were asked to characterize the feelings of the supervisor in the incident, the supervisors themselves took up the cudgel of judgment, arguing that the supervisor was disloyal and not a team player. The insight discussed in the small groups, that the supervisor felt browbeaten and was simply complying, was not mentioned in plenary.

This is of course one measure of the plant's judgmental culture and the supervisors' consequent fear of speaking up in public. But Hirschhorn's own feelings at that moment give some insight into the dynamics of the links between upper management and the supervisors. Just as the upper manager in the incident felt betrayed, *Hirschhorn also felt betrayed by the supervisors who at that moment were not supporting him in exploring the critical incident.* The feeling was profound and shocking, and Hirschhorn, talking very much out of his own unconscious voice, found himself emphatically saying, "The voice of the supervisor cannot be heard in this room." Complete silence followed.

This event highlights two important dimensions in the process of "uncovering work." First, the seminar dynamic "transferred" the relationship between the supervisors and the upper managers onto the relationship between the instructor and the seminar. Issues of betrayal which lie at the core of the critical incident came between Hirschhorn and the seminar participants. Second, the recreation of this dynamic in the seminar gave Hirschhorn an emotional as well as a cognitive understanding of the relationship between levels of authority in the plant. Consequently, his unplanned challenge to the seminar had the added authority of being both deeply felt and spontaneous. While such moments are always open to further interpretation, it was Hirschhorn's and the Wharton staff's impression that the silence following his challenge represented the silence of assent, of recognition. Such moments of uncovering work differ from the work of challenge described earlier because it surprises both the trainer and the participants. But it is this surprise that give the moment and its associated learnings authenticity.

The following chart highlights the different kinds of roles we took in working with the supervisors and other roles over the course of the seminar.

Character of Conversation	Role of Training	Nature of Learning
Exploratory	Advance conversation	Study of themes
Focused	Challenge thinking	Study of paradoxes, contradictions
Uncovering	Links thoughts to feelings	Discovery of suppressed experience

Training as a Transitional Space

The Impacts of the Seminar

The seminar stimulated a great deal of cross-talk between roles and levels. As the seminar program chart shows, upper managers joined the supervisors in every program. After the second seminar, they began considering what practices they might introduce or change to implement some of the learnings of the seminar itself. The seminar's impact was less on the skills of the supervisor and more on the context within which supervisors and other roles worked together. After the third seminar, an upper manager compiled a list of changes made in the plant as a result of the seminar itself. The following table (modified and disguised to preserve the plant's confidentiality) presents this list.

Actions Taken as a Result of the Wharton Seminar

1. More vertical meetings between the upper managers, the division managers, and the supervisors

2. Labor relations seminars held with small groups of supervisors to increase the latter's understanding of the contract and its application

3. Monthly feedback of product line data to supervisors, linking results to forecasts

4. Implementation of an electronic message capability to all supervisors
5. More supervisors attending shop council
6. A project team with supervisors to study the problem of work restrictions
7. Supervisors now have higher budget limits on storeroom withdrawals and sending operators for education.

As this list suggests, the changes, while incremental, did not magically transform the culture of the factory, but they did reflect upper managers' commitment to relinking the supervisors with their own chains of commands as well as to support functions. Interestingly, only two of the initiatives -- the labor relations seminars and the review of work restrictions -- relate directly to the supervisor's authority over operators. The others focus on the supervisors' relationships to other units of the "value-added chain" (e.g., product line data availability), to their own managers, or to the plant as a whole (e.g., the shop council meetings).

These initiatives thus match the Wharton team's original hypothesis that the supervisor role had become an increasingly complex one because supervisors, in taking their roles, focused increasingly outward and upward rather than downward.

The Transitional Space

Clearly, this list does not begin to address the deeper challenges the plant faced as a total social system. Designed to reintegrate the supervisors into the plant social system, the actions upper managers took were sensible and useful. But they faced much broader problems. The links between engineering and the shop, the relationship between the shop and staff functions, the strategic position of the plant in the company and the marketplace -- all these issues, while broached in the seminar, could not be resolved within it.

We came to the conclusion that a training program linked to the problem of cultural and structural change functions best as a *transitional space*. It does this in three ways. First, it functions as a social setting in which difficult issues of authority, purpose and role can be safely discussed for the first time. Such discussions provide the shared data and insight for further working through the extant chain of command and actual working relationships in the organization.

Second, it functions as a transitional space by providing both a real and simulated environment for changing role relationships. Thus, for example, the critical incident in the second seminar reproduced the feelings of fear and betrayal that distorted the real relationships between upper managers and supervisors in the factory social system. Similarly, our relationship to the seminar participants as we worked to redesign and develop the seminar reproduced feelings that participants had about learning and authority in the factory itself. Thus, by invoking social processes that take place in the factory within the seminar, seminar participants have the opportunities to improve these processes without feeling unduly anxious or isolated.

Third and finally, the seminar highlighted the process of transition itself, of learning and developing, as we and the participants deepened our relationships to each other and our understanding of the plant as a social and cultural system. This feature of the training space -- as an occasion to learn how to make transitions, and to learn how to learn -- may prove to be training's most important contribution to the broader problems of cultural change in factories.

IV. Some Common Themes

The three cases discussed in this report -- their presenting problems and training vehicles -- are all quite different. Yet several common themes exist across these cases, highlighting challenges to training in a wide variety of industrial settings. Eight themes are of particular importance.

First, we cannot think of training as a narrow activity confined to classroom experience and designed to give workers particular technical skills. This image of training is not wrong, rather it is too limited. *Training is a vehicle for organizational development and therefore facilitates organizational functioning in many ways.* It helps people take up new roles rather than just new skills, it helps links roles and levels together in new ways, it creates a shared language of problem solving which helps people from different functions work together; it helps shape a climate in which people believe that, in fact, management cares about its people. Technical skill acquisition is one important subset of training's broad purposes, but it is only a subset. Thus consider the following chart.

	Cookie-Foods, Inc.	Circuit, Inc.	Electro, Inc.
Training to help give new problem solving skills	X	X	
Training to give new social system skills	X	X	X
Training to help shape new roles	X	X	X
Training to create an integrating language of problem solving.	X		
Training to improve authority relationships			X
Training to give new technical skills		X	
Training to help people think of themselves as learners	X		X

As this chart suggests, at each factory, training served more than one purpose while the focus of training differed among them. For example, the training at Electro, Inc. was specifically designed to stabilize authority relationships between the supervisors and upper management, while, through the critical incident technique, it helped improve the supervisor's interpersonal skills. At Cookie-Foods, Inc. by contrast, the training focused on problem solving skills, and by helping to link the bakers to the SPC program, it provided workers and managers with a common language for solving problems. Finally, at Circuit, Inc. the prospective training program (recently adopted as one part of its human resources program) focuses on technical and social skills that workers will need in the plant's emerging project culture.

Second, in evaluating the impacts of training we cannot therefore simply look at skills acquired. Indeed, as the case of Cookie-Foods, Inc. suggests, unless skills are reinforced through a new set of roles and relationships, the training will have ultimately "failed" even though trainees can pass competency tests upon completion of a course. Similarly, as we saw in the case of Electro, Inc, in assessing the impact of the seminars, upper managers examined organizational changes which reshaped the relationships between supervisors, managers, and operators. This suggests that training is more effectively assessed by examining how it contributes to a process of organizational development. Its impact then depends on both its ability to support organizational change *and* on the depth and scope of the change itself. The following six-fold table exemplifies this approach.

Training's contribution to an organization development (OD)_program *

		High	**Med**	**Low**
The impact of the OD program on organizational change	**High**		Electro	
	Med			
	Low	Cookie-Foods		

***Circuit Inc.'s new training programs are still to new to be evaluated.**

Third, this means that in trying to understand training's impact we cannot separate it from the broad economic and strategic context which shapes, enables and delimits all efforts at organizational renewal and development. For example, as we have seen, at Cookie-Foods, Inc. a sudden expansion in production and hiring made it difficult for Berg to invest time, effort and attention in the task force teams he had helped start. Similarly, the challenges to training at Circuit, Inc. were shaped by the plant's strategic role in the company.

Fourth, as this approach suggests, we must acknowledge the problem and challenge of linking the training process to an organization's structure and process. In the case of Cookie-Foods,Inc., we saw how the operators could not transcend their tacit approach to problem solving unless new relationships between managers and workers emerged in the bake shop. Similarly, at Circuit, Inc., the development of new skills challenged two features of the organization design -- the team-based system for allocating jobs and training opportunities, and the pay-for-learning system for regulating learning and upward mobility. The new skills were linked to project tasks which cut across the teams, while training had to take place increasingly in the classroom rather than on the job.

Finally, at Electro, Inc., the senior management faced the problem of taking the learnings and experience from the training setting and changing actual organizational practices. As we saw, the training environment at Electro, Inc. could function at most as a transitional space between insight and action, but it could not substitute for action within the organization itself.

Fifth, training programs will partly reflect the ongoing politics of organizational change and development. They are not simply technical responses to technical problems but rather reflect tensions and compromises among the different interest groups in the organization. For example, at Cookie-Foods, Inc., senior management's uncertainty about the impacts of SPC on capital spending delimited its impact, while the human resource manager's plans for modernizing the personnel function were implemented in a traditional industrial relations system. Similarly, at Circuit, Inc., management's conception of training and skill development took place against a backdrop of some workers' desire to get out of factory work and learn more white collar skills. Finally, the political realignments that the Deming program stimulated at Electro, Inc. -- i.e., the coalescence of the operators and upper managers (seemingly) against the first line supervisors -- alienated the latter and led to the development of the second supervisory training program. That program was thus embedded from the start in the politics of intergroup relationships.

Sixth, workers' competence, their ability to learn and practice skills, are linked to the dynamics of a problem situation, as well as to their abilities or the objective complexity of the job. To be sure, workers who repair machines need to understand how the machine works -- this is objective knowledge. But their capacity to be competent, to translate abstract knowledge into competence to perform as well as to learn, is inextricably linked to the group processes that shape what they observe, how they feel, what risks they take, what they fear.

We cannot think of training as simply classroom activity in which knowledge is "injected" into people. Rather training, when it is successful, authorizes people to "try on" some new skills, some new practices, and to rework their relationships so that these new practices fit into their environment. Training stimulates a process of development and is therefore the beginning rather than the end of skill acquisition.

For example, as we saw in the case of Electro, Inc., supervisors who wanted to manage the difficult workers more successfully had to rethink why they first took up parenting roles and then wound up being victimized by those workers' undisciplined behavior. How they practiced supervision was linked to the role and relationship systems that shaped their practices.

Similarly, the bakers at Cookie-Foods, Inc. found themselves in a similar situation. They would not be able to think more broadly, to develop inner causal maps of a process problem that transcended their sensory knowledge of the situation, if they were afraid of looking foolish or stupid.

Seventh, since workers are adults who need to feel authorized to practice in new ways, training must be based on the principles of adult education. Adults learn when they are offered genuine choices, and when the new knowledge can improve their practice. Then they can link what they currently know to what they wish to learn. Training, to be successful, cannot be based on practices derived from the training of children, where students are given few choices, experience is ignored, and the trainer is the all-knowing expert. To be sure, classroom training is important, and as we saw at Circuit, Inc., can become more so as technologies change with greater frequency. Rather, the roles people take up within a classroom must be less stereotyped, less based on the teacher-pupil model of public schooling.

Thus, for example, while working within a modified seminar format, the instructors in designing the training program for Electro, Inc. developed the training materials from the experience and cases of the supervisors themselves. Similarly, at Cookie-Foods, Inc., the instructors designed experiential learning activities which opened up several paths for learning, rather than just one.

Indeed, this explains why "on-the-job training" remains so powerful and effective. The informal teacher or mentor teaches in the context of practice as actual problems emerge. Through observation, he or she takes account of the "apprentice's" prior experience and strengths, and authorizes the apprentice, by sanctioning practice runs and trials by fire, to try on new skills without being afraid of being ridiculed for making mistakes. New training mechanisms should not simply dispense with these features of on-the-job training but rather find ways of incorporating them within more systematic and cost effective methods for teaching and learning.

Eighth, this different approach suggests that trainers cannot hope to control the training encounter but must instead be open and vulnerable to the surprises that genuine learning produces. Such an approach to training may prove difficult to achieve. The economics of training always push in the direction of designing repeatable events with known inputs and measured training outputs. As training becomes even more significant, we need to find a new melding of the formal and the informal, the off-the-job and the on-the-job, the instructional setting and the facilitating setting, to effectively and efficiently help companies and their employees develop and apply new technical and social skills.